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WORLD OIL

Established 1916 as The OIL WEEKLY

SOME FACTS ABOUT 'OIL PRICE FACTS'

We're Flattered . . .

. . . by the thousands of reprints that have been ordered and the compliments that have been passed along on the supplement, "The Facts About Oil Prices," included in the March issue of WORLD OIL. *"It should go a long way toward acquainting oil men with the facts concerning the price of oil,"* writes the president of a major oil company.

That is one of the purposes . . . but the aim is even broader . . . and is supported by further comment from the same executive. *"It should do even more to help those understand it (price of oil) who are not as familiar with the subject as oil people. . ."*

Some who have ordered reprints . . . major companies, independents, individuals and associations . . . have indicated that the pamphlets will be given to their employes to pass along to friends outside the industry . . . the grocer, the baker and the milkman. *"It is more effective when presented by someone known to you,"* says one person, *"than if it merely comes through the mail from an unknown party."*

The supplement was prepared with non-oil people in mind. It will be most effective if put into the hands of the general public. The idea of making it available to employes to pass to friends and neighbors is one good way of accomplishing this. If this is done on a wide enough basis the message can be carried to millions of people. The marketing division has an especially fine opportunity in non-oil producing states, because this is where the industry's public relations is the poorest and the marketing division is the only part of the industry operating in such areas.

Some companies are including the pamphlet in annual reports. Others are distributing it to dealers and jobbers.

An API official writes: ". . . *a superb job . . . one of the finest anyone has come up with . . .*" We are justifiably proud of being able to have a small part in spreading the real oil price story . . .

. . . But We're Not Satisfied

"The Facts About Oil Prices" is already in its third printing. We want to print more. *"An outstanding job . . . both needed and helpful . . ."* writes an IPAA official.

The need is obvious. And as long as this pamphlet will help fill this need, we'll furnish reprints at our printing costs . . . in the hope even more copies will find their way into the homes of the millions of people outside the oil industry who help formulate public opinion.

Turn the Page ▶

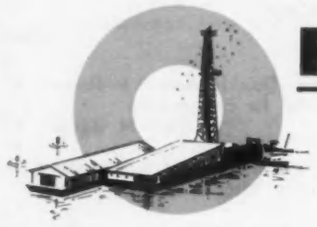
a QUICK LOOK at this issue . . .

☐ **Prices of oils are relatively low** despite recent increases. New prices are not only economically justified but essential to assure future supplies of oils for national defense and emergencies. There was too little profit in oil before the price increases to promote vigorous development of new reserves. The U. S. was coming to depend too much on foreign oil, thereby jeopardizing the national welfare. For a clear picture of the price situation as described to Washington officials by the president of Humble Oil & Refining Company, Turn to **Page 82. New Prices Needed to Help Assure Oil for Emergencies.....Hines H. Baker**

☐ **More fire fighting facts** are explained in this third installment by a recognized authority on the subject. Here he discusses proper steps to control and extinguish crude oil tank fires . . . including his own development, air agitation. **Page 90. How to Control Crude Oil Tank Fires.....J. L. Risinger**

☐ **Proved U. S. reserves of crude oil,** natural gas liquids, and natural gas were increased during 1956 and were at new highs at the end of the year. Canadian reserves also were expanded to new record levels. These results were revealed by the latest annual reports on reserves by American Petroleum Institute, American Gas Association, and Canadian Petroleum Association. **Oil and Gas Reserves at New Highs in U. S. and Canada.....Page 103**

NEXT MONTH . . .



FFSHORE

WHETHER YOU HAVE a vital interest or an idle curiosity in offshore operations, you'll find next month's WORLD OIL packed full of "must" reading. Significant facts and figures will show the magnitude of the task of finding and recovering oil from beneath the coastal waters.

This Special Report will cover:

- **ECONOMICS** of the vast offshore exploration, drilling and producing activities.
- **EXPLORATION** developments and methods.
- **DRILLING** trends and a preview of the types of rigs that will be drilling in ever increasing depths as the search for oil moves seaward.

A Progress Report . . . on Exploration Activities

☐ **A record convention** climaxes a banner year for AAPG and SEPM. The two groups join forces for a meeting in St. Louis. Here's a review of the convention theme and a list of officers. **AAPG-SEPM Hold Annual Convention in St. Louis.....Page 110**

☐ **Radical improvements in seismic processes** promise an improved ratio in finding productive horizons. Turn to **Page 113. Magnetic Recording—a New Key to Data Interpretation....Gilbert M. Wilson**

☐ **A new land cable geophone** which permits a rapid system of planting is described in the article beginning on **Page 119. New Geophone Will Improve Seismic Field Production.....Alan D. Waldie**

☐ **Iron out your problems** associated with magnetic recording and head construction. Beginning on **Page 123,** the author discusses some general aspects in . . . **New Developments Made in Direct Recording Head .....A. S. Badger**

☐ **See how a study of surface radiation characteristics** enables a trained observer to locate structural conditions which may be favorable for the production of oil. The story starts on **Page 126. Detecting Subsurface Faults by Radioactive Measurements..... W. J. Williams and Phillip J. Lorenz**

☐ **Splicing facts and figures together** for a mountain top look at exploratory prospects will play an important role in the over-all exploration effort. Heretofore, figures have followed exploration methods from the first day, but little has been done to give meaning to them. See **Page 129. Statistics Play Vital Role in Exploration .....Frederic H. Lahee**

☐ **Streamline exploratory methods** by adopting new, speedier and less expensive methods. Not a substitute for established conventional methods, the new approach is intended to reinforce geophysical prospecting campaigns. Turn to **Page 134. Modernized Core Drilling for Structure.....R. W. Biggart**

☐ **Florida's oil prospects are good.** Geophysical exploration by all methods has had generally nega-

WORLD OIL, published every month except semi-monthly in February and August. Entered as THE OIL WEEKLY as second class mail matter December 23, 1916, at postoffice at Houston, Texas, under the act of March 3, 1879.

REPORT . . .

- **PRODUCTION** practices and problems that will include a discussion of present workover practices and some tools and techniques now in the development stage.
- **LOGISTICS, TRANSPORTATION and COMMUNICATIONS . . .** three of the important behind-the-scenes activities vital to offshore activity. The scope and magnitude of these activities will be discussed.

Each page of this Special Report on Offshore Operations is designed to place all the pertinent facts at your finger tips. Whether you are in Canada or South America . . . West Texas or Pennsylvania, this collection of information will answer your questions on . . . *just what makes offshore operations so important?*

Don't miss it in your May issue of WORLD OIL.

During the Past Year

tive results. But if exploratory wells can be drilled for less cost in the future, results should improve. Limited subsurface information indicates that Cretaceous and lowermost Tertiary limestone should be productive along trends spanning the southern parts of the peninsula, roughly parallel to the south flank of the Ocala uplift. **Page 140. South Florida's Oil Prospects Are Good**.... **H. T. Brundage**

☐ **History teaches** in this review of the application of gravitation devices. Certain magnitudes are derived with the use of the gravimeter and torsion balance are evaluated by comparison in the article beginning on **Page 146. Use of the Gravity Meter as a Torsion Balance** .....**V. G. Gabriel**

☐ **You can't replace brain waves.** Exploratory science has been enhanced greatly during the past decade by new and improved oil finding tools. But this author says a time has come to ask the question . . . *Is the importance of scientific apparatus being given priority over the scientific brain?* See **Page 153. "Brain Waves"—Our Real Oil Finding Tool**..**Jon M. Parker**

THIS MONTH . . . *continued*

DRILLING ARTICLES

☐ **Here is a new approach** to electric log interpretation. Beginning on **Page 159** is the first of a three-part series based on interpretation of oil wet rocks, fractured rocks and shaly sands. It's entirely new. Based on the determination of relative permeability to the various fluids, it provides a new method of predicting well productivity from electric logs. **Formation Evaluation by Log Interpretation**..... **S. J. Pirson**

☐ **One operator has saved money** by using a slug of heavy mud when the liner wiping plug reaches bottom. The drill pipe can be pulled dry and excess cement will be displaced up the hole and away from liner top. Read about it on **Page 169. Mud Slug Cuts Liner Cost** .....**J. J. Fowler**

☐ **Drainhole drilling techniques** developed in California are proving successful in Oklahoma. Low porosity, low permeability formations with low gravity crude have been drainholed successfully. Drainhole also opens additional formation face to fracturing operations. Turn to **Page 170** for details. **Drainhole Drilling Increases Oil Recovery**.....**Myron Buttram**

☐ **New tools and techniques** have been added to an old method of "fish" recovery. The third part of this series on **Fishing Tools and Techniques** tells how this has meant savings in time and equipment. See **Page 176. Washover Operations**...**Weldon L. Medders**

☐ **More accurate formation interpretation** and faster penetrations rates are resulting from the development of a non-fluorescent oil which can be added to drilling mud. The article on **Page 184** compares the benefits and costs of this oil with diesel and crude. **What Non-Fluorescent Emulsion Muds Provide** .....**G. G. Baker**

PRODUCTION ARTICLES

☐ **Simplify your deliverability forecasting** for gas reservoirs. Here is an explanation of an assignment that constantly confronts reservoir engineers. The step-by-step approach and the use of examples make it easy to understand. See **Page 193. Estimate—Don't Guess on Gas Reservoirs**.....**Jack R. Fraser**

☐ **Optimum operating efficiency of electric motors** on an oil field lease is no accident. It is the result of planning and realization that the least expensive hookup is rarely the most economical. Beginning on **Page 200** is a practical picture of a typical installation.

Turn the Page ⏵

THIS MONTH . . . *continued*

Engineering vs. Economics in Today's Electric Leases.. J. H. Day, Jr.

☐ **Fracturing shoestring sands** during a waterflood has proved successful in Kansas. Resulting increases in injection rates and well productivity have put the field on a paying basis. For details of the operation that pioneered this technique read . . . **Fracturing Shoestring Sands Successfully**.....Page 210

☐ **A closed injection system** has considerable advantage in minimizing corrosion and preventing plugging of injection well bores. Two representative systems now in operation are discussed in the article starting on **Page 220. Closed Systems Protect Flood Water**.....L. E. Sharp

☐ **A handy tool to keep in your file** is the nomogram for wash tank syphon design on **Page 233.** You'll also find an explanation of how to use it. **This Nomogram Can Simplify Syphon Design**..... F. Schellmandein

INTERNATIONAL ARTICLES

☐ **Extremely important to the world oil picture** are the recent discoveries in Algeria, French Equatorial Africa, Angola and Nigeria. They are particularly important to the consumer nations of Western Europe. For an up-to-date summary of African oil developments read . . . **African Success Highlighted by Blocking of Suez**.....Page 235

☐ **The world's largest marine offshore oil field** at Safaniya will be linked with the Ras Tanura refinery and terminal when Arabian American Oil Company completes its 142-mile, 22-inch, $21 million crude oil pipe line. See **Page 238. Saudi Arab Offshore Field to Go On Production**.....H. T. Brundage

☐ **Cuba's most important oil development** in 1956 was the discovery of what appears to be its first salt dome. Turn to **Page 240** for a geologic evaluation of the three significant tests drilled by Cuban Kewanee Oil Company on a farmout from The Atlantic Refining Company and a summary of prospects. **Cuba's North Shore Offers Good Exploration Prospects**.....Harry Wassall

☐ **Does deeper production exist** in France's Parentis oil field, discovered in 1954? The field has estimated reserves of 175 million barrels at 7500 feet. Proposed is a deep test to determine whether deeper production does exist. **New Test to Determine Deeper Prospects at Parentis**.....Page 242

☐ **India wants more oil** produced within her own boundaries. Domestic demand is exceeding the domestic supply by 95 percent. These factors have combined to spur activity. Indications are that terms under which private capital from abroad can operate will be improved. See **Page 243. India Opens Door Wider to Private Capital**.....Don Kliewer

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WORLD OIL and THE COMPOSITE CATALOG for the drilling-producing industry.

PETROLEUM REFINER and THE REFINERY CATALOG for the refining-natural gasoline-petrochemical industry.

PIPE LINE INDUSTRY and THE PIPE LINE COMPOSITE CATALOG (first edition to be issued in July, 1957) for the oil and gas pipe line industry.

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Indexed by Industrial Arts Index and Engineering Index

Looking Ahead . . .

Lower Oil Demand Requires Less Supply . . . The scheduled sharp cut in Texas allowable crude production in April reflects prospective decreases in both exports and domestic consumption. The April allowable of 3,564,665 barrels daily will represent a cut of 224,710 barrels. Less U. S. oil for Europe will be needed henceforth, as Middle East oil begins moving in larger volume through the Mediterranean. Less oil for the U. S. itself will be required with the waning of the heating season. For the next several months the industry must gear crude production and refinery runs to smaller exports and lower total domestic consumption of oils.

•

Full (Business) Steam Ahead . . . The Commerce Department and the Securities Exchange Commission say reports that business expansion is slackening are not borne out by their latest survey. This tabulation produced, they said, $37.5 billion worth of new plant and equipment planned in 1957 by American business.

•

Atmosphere Improves for Oil Industry . . . A healthier atmosphere for the oil industry is the result of frank testimony by industry leaders who have appeared before Congressional bodies. They have explained price hikes and defended their companies from charges of non-cooperation and monopolistic practices in connection with the Oil for Europe program.

Observers predict the defeat of Senate Bill S-11, the proposed amendment to the Robinson-Patman Act, relating to competitive price cuts by jobbers and retailers, despite Sen. Estes Kefauver's desperate attempts to save this piece of legislation. Kefauver's tactics are backfiring on him and other oil industry baiters in the Congress.

Oil's position is being made clearer to the nation. The presentations of facts should help to reduce the tendency to make the oil industry the nation's "whipping boy."

•

Drilling Boom Ahead for Four Corners . . . The projected 500-mile crude pipe line outlet for oil from the prolific Four Corners area, terminating in Los Angeles, will open up a "lagging" oil province to intense exploration. Considerable crude oil from the Four Corners area has either been shut in or subjected to an extra "tax" represented by truck hauling charges ranging from 25 to 40 cents per barrel. Hundreds of locations will now be drilled in view of the pipe line outlet.

Leaders in the project are Shell Oil Co. and Standard Oil Co. of California. Shell will construct and operate the proposed line as agent for the operators, the Four Corners Pipe Line Co. Shell has completed most of the preliminary engineering work. Construction is slated to start in April. Crude shipments will start from the Four Corners area late in 1957.

Double Benefits Due from Highway Building . . . The mammoth highway building program will benefit the oil industry directly and indirectly. It will immediately boost sales of asphalt, diesel oil, lubricants, gasoline, and other products for use in

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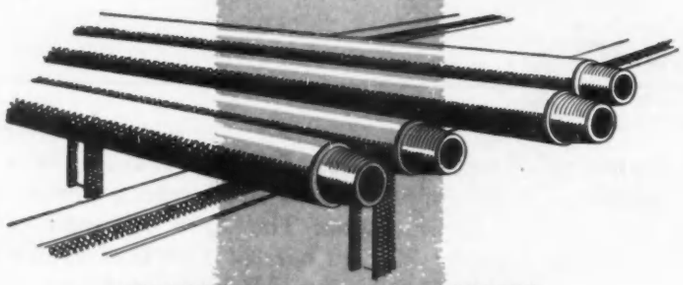

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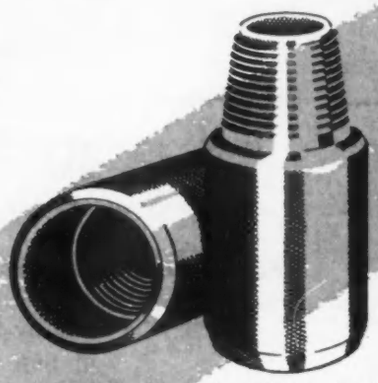

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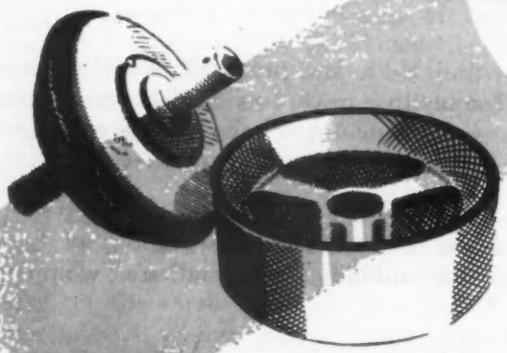

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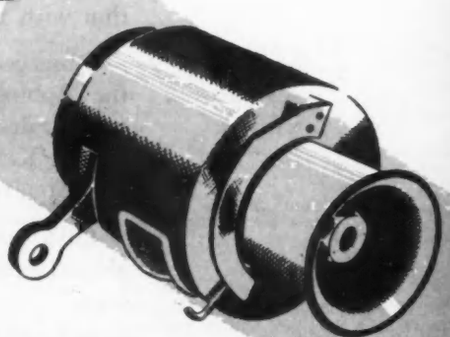

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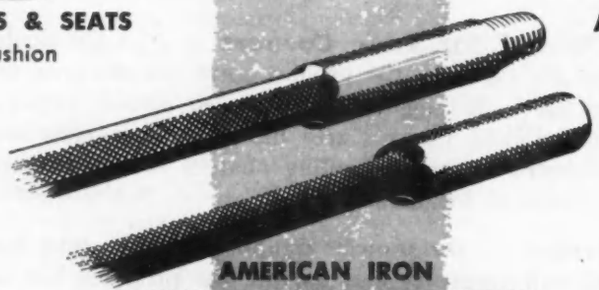
Makeup and Breakout



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highway construction. Ultimately, the better highways will expand use of petroleum products by motorists.

Federal, state, county, and local governments will spend more than $100 billion on roads in the next 13 years. About half will be federal money. Highway spending will reach $5.8 billion this year, compared with $5.1 billion in 1956. It may top $8 billion by 1960.

•

California Offshore Leasing Delayed . . . Awarding and processing of California offshore wildcat leases may be delayed for at least a year. The California legislature has asked that further leasing be postponed until existing royalties are reviewed and possibly modified. Only two wildcat leases have been awarded. Some half dozen are in the processing stage. Seismic and core hole exploration work offshore doubtless will continue.

Further processing of wildcat acreage cannot proceed until the legislature passes new legislation or adjourns without having taken any action. Adjournment is scheduled for June 14. Under existing law, wildcat leases are awarded on the basis of 12½ percent royalty and bonus. If the royalties are raised, some operators may be priced out of the offshore picture, as the deep water development will be costly and hazardous.

•

New Tool for Permanent Completions . . . A through-tubing bridge plug may be added shortly to the equipment being developed for permanent completion work. It is capable of travel through 2-inch tubing and will expand to hold cement in 7-inch casing. This will allow a zone to be perforated, tested and then isolated, to permit further tests higher up without pulling the tubing.

•

More Exploration in Philippines Likely . . . Prospects are bright for an intensified oil exploration program in the Philippine Islands. The government has granted 49 concessions, covering almost 8 million acres. It is likely that more and more U. S. technical assistance will be routed to the islands to push operations. Too, it is anticipated that other companies will build more refineries in the area, which is served currently only by the unit operated by Caltex in Batangas province.

•

FPC Suggests Changes in Gas Law . . . FPC has suggested five major changes in the Natural Gas Act. It says they "are not inconsistent" with the new gas bill drawn up by oil and gas leaders. Changes include: (1) Establishment of a new gas pricing standard that will eliminate required use of the rate base pricing method . . . (2) Elimination of certificates of public convenience and necessity for natural gas producers . . . (3) The same treatment for independent producers and interstate gas pipe line producers concerning prices and evaluation of natural gas . . . (4) Elimination of sales contract clauses between independent producers and interstate pipe line companies which allow price changes for purchase due to changed prices on gas resold by purchaser; and different payment, or payment offer, by purchaser or other purchasers to seller or other sellers . . . (5) Elimination of cost and revenue consideration for other products obtained in conjunction with natural gas production, including oil and liquid hydrocarbons.

•

New Bearing Lubricant? . . . Gas-lubricated bearings are coming out of laboratory development stage and show great promise for the future. Bearing shaft rides a film of gas separating it from the bearing surface. In one type, compressed gas is supplied continuously to bearing. Advantages: No possibility of contamination of products by lubricant, far less friction, no limitation to bearing temperatures.

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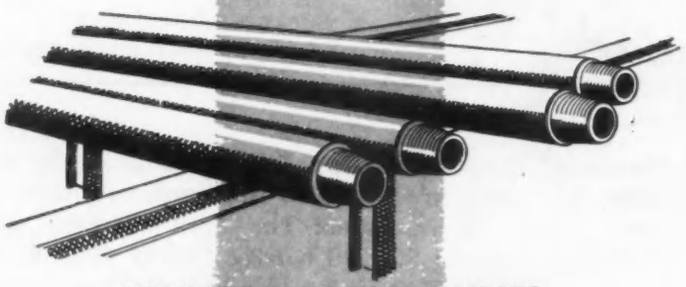

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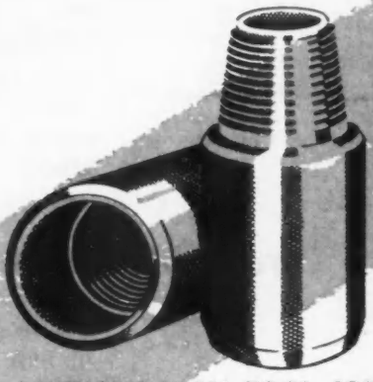

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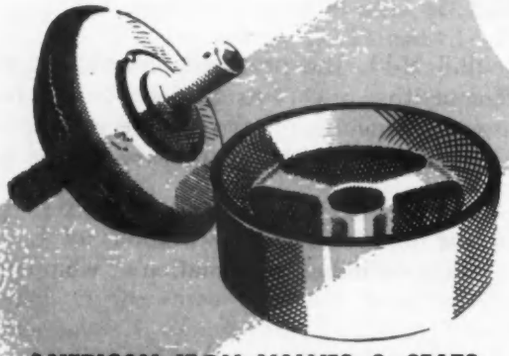

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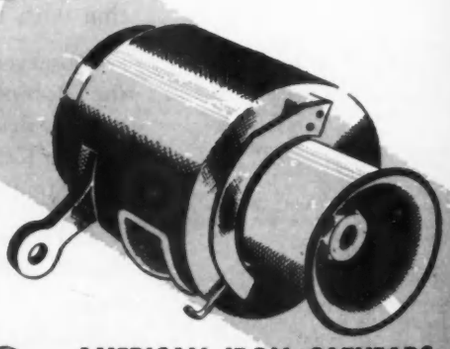

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highway construction. Ultimately, the better highways will expand use of petroleum products by motorists.

Federal, state, county, and local governments will spend more than $100 billion on roads in the next 13 years. About half will be federal money. Highway spending will reach $5.8 billion this year, compared with $5.1 billion in 1956. It may top $8 billion by 1960.

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California Offshore Leasing Delayed . . . Awarding and processing of California offshore wildcat leases may be delayed for at least a year. The California legislature has asked that further leasing be postponed until existing royalties are reviewed and possibly modified. Only two wildcat leases have been awarded. Some half dozen are in the processing stage. Seismic and core hole exploration work offshore doubtless will continue.

Further processing of wildcat acreage cannot proceed until the legislature passes new legislation or adjourns without having taken any action. Adjournment is scheduled for June 14. Under existing law, wildcat leases are awarded on the basis of 12½ percent royalty and bonus. If the royalties are raised, some operators may be priced out of the offshore picture, as the deep water development will be costly and hazardous.

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New Tool for Permanent Completions . . . A through-tubing bridge plug may be added shortly to the equipment being developed for permanent completion work. It is capable of travel through 2-inch tubing and will expand to hold cement in 7-inch casing. This will allow a zone to be perforated, tested and then isolated, to permit further tests higher up without pulling the tubing.

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More Exploration in Philippines Likely . . . Prospects are bright for an intensified oil exploration program in the Philippine Islands. The government has granted 49 concessions, covering almost 8 million acres. It is likely that more and more U. S. technical assistance will be routed to the islands to push operations. Too, it is anticipated that other companies will build more refineries in the area, which is served currently only by the unit operated by Caltex in Batangas province.

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FPC Suggests Changes in Gas Law . . . FPC has suggested five major changes in the Natural Gas Act. It says they "are not inconsistent" with the new gas bill drawn up by oil and gas leaders. Changes include: (1) Establishment of a new gas pricing standard that will eliminate required use of the rate base pricing method . . . (2) Elimination of certificates of public convenience and necessity for natural gas producers . . . (3) The same treatment for independent producers and interstate gas pipe line producers concerning prices and evaluation of natural gas . . . (4) Elimination of sales contract clauses between independent producers and interstate pipe line companies which allow price changes for purchase due to changed prices on gas resold by purchaser; and different payment, or payment offer, by purchaser or other purchasers to seller or other sellers . . . (5) Elimination of cost and revenue consideration for other products obtained in conjunction with natural gas production, including oil and liquid hydrocarbons.

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New Bearing Lubricant? . . . Gas-lubricated bearings are coming out of laboratory development stage and show great promise for the future. Bearing shaft rides a film of gas separating it from the bearing surface. In one type, compressed gas is supplied continuously to bearing. Advantages: No possibility of contamination of products by lubricant, far less friction, no limitation to bearing temperatures.

Good Wells Make Good News

April, 1957

SANDFRAC®—a Dowell developed service—is one of the most widely used formation fracturing treatments. Most lease crude oils can be used in Sandfrac. If necessary, they can be modified on location with addition agents to control thickness, fluid loss and emulsions. If suitable lease crude is not available, special refined oils can be used. This versatility, plus Dowell's experienced personnel and dependable equipment, make Sandfrac a profitable treatment for many wells. Want proof? Just look at these cases.

- **Duval County, South Texas**—(Old Well)—Completed in Queen City Sandstone through perforations 5129-5133 feet in April 1956, and tested 104 BPD 43.7° gravity oil. By June, well had gone completely to water. It did not respond to acid or emulsion breaker treatments. Then it was fractured with Sandfrac, using 5000 gallons of 21° gravity crude from another zone, and 5000 pounds sand. After treatment, well produced at field allowable of 102 BOPD. At market price of $3.10 per barrel, $534.33 treatment *cost was recovered in less than two days.*

- **Kay County, Oklahoma**—(New Well)—Open hole completion in Mississippian Chat 4148-4180 feet. Well tested 5 BOPD before treatment. Sandfrac, using refined oil, was selected because of crude storage costs and relatively low acid solubility of chat in this area. 500 gallons of Mud Acid spearheaded 10,000 gallons oil and 20,000 pounds sand. Injection rate down 5½" casing averaged 25.2 barrels per minute. *Six months after treatment, production had leveled off at 40 BOPD.*

- **San Juan County, New Mexico**—(New Well)—Completed in Gallup formation of the Bisti Field. Before treatment, well tested 3.5 barrels oil per hour. Sandfrac, with 35,000 gallons lease crude and 26,000 pounds of sand, was used. Injection rate down casing was 50 BPM. *After treatment, well tested 62 BOPH.*

- **Lawrence County, Illinois**—(New Well)—Completed in tight Benoist Sandstone in open hole 1860-1873 feet, well tested only a show of oil before treatment. Mud Acid spearhead preceded Sandfrac, using 10,000 gallons of lease crude, 10,000 pounds of sand and 250 pounds of F.L.A.* (Fluid Loss Additive). Injection was down 5½" casing at 29 barrels per minute. Production after treatment was 110 BOPD, stabilizing at 65 BOPD. At market price of $2.90 per barrel, *cost of $1,700 treatment was recovered in approximately one week.*

Dowell Engineers can help you tailor Sandfrac to the requirements of your well, or they may suggest another Dowell treatment for better results. Either way, it pays to deal with Dowell. For more information or service, call any of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service, or write to Dowell Incorporated, Tulsa 1, Oklahoma.

*Trade Mark of Dowell Incorporated

Services for the oil industry DOWELL

A Service Subsidiary of The Dow Chemical Company

Must Limit U. S. Imports Quickly

Nothing has been done to restrict U. S. oil imports, although it has been two years since adoption of a means for measuring desirable import volumes.

In February, 1955, the President's Cabinet Committee on Energy Supplies and Resources proclaimed imports in excess of their 1954 ratio to domestic crude production (16.6 percent) a danger to national security. In June, 1955, Congress enacted the Defense Amendment to the Trade Agreement Act, empowering the president to limit imports to 16.6 percent of domestic crude production.

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On several occasions since that time the Office of Defense Mobilization has requested voluntary curtailment of U. S. imports. Yet imports rose to 18.3 percent of U. S. crude production in 1955, and then to 19.7 percent in 1956. Imports exceeded their 1954 ratio to production by 43 million barrels in 1955, and 81½ million barrels in 1956. Even during the first two months of 1957, when U. S. production was at new peaks and Suez blockage was hindering Middle East shipments, import ratio to production averaged 18.3 percent.

Latest request for voluntary curtailment was on last March 6. However, this was one of Defense Mobilizer Flemming's last acts before vacating the office. The attitude of his successor is not known, nor how long it will take his successor to become familiar enough with the situation to act. Nor does anyone know how much time will be required to complete the "renewed study" announced by Flemming.

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Imports threaten to become more severe in the near future than ever before. The Suez Canal is expected to reopen soon, permitting large quantities of Middle East oil to reenter international markets after being absent since last October.

This will bring about a sudden sharp decline in Europe's need for U. S. crude. Unfortunately, this will occur at a time when U. S. consumption invariably reaches its lowest point of the year. Demand for U. S. oils may be as much as 1½ million barrels per day less in the second quarter of 1957 than record first quarter demand. Third quarter demand will be only slightly larger than in the second quarter.

This means an immediate flood of oil unless both U. S. imports and producing rates are cut substantially in the months ahead. If U. S. producers are forced to absorb the whole reduction, it will not take long to severely damage the oil industry of this country.

Time is running out, action should not be postponed any longer. The means of measuring import volumes has been approved. It should be used—and quickly.

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National security is involved in a big way. A strong domestic U. S. oil industry capable of providing a readily available supply adequate for national emergencies is essential. Without oil, factories would grind to a sudden halt and people could not get back and forth to work. Chaos would reign. Military operations would be helpless without fuel for planes, tanks, ships and jeeps. Defeat would be certain.

An abundant U. S. at-home supply made it possible for America and her allies to "float to victory on a sea of oil" in World War II. The U. S. shipped twice as many tons of petroleum to fighting forces in World War II as all other tonnage combined (food, munitions, etc.). More recently, Western Europe had to turn to U. S. oil when loss of oil supplies due to blockage of Suez threatened economic and industrial collapse. The latter event demonstrated beyond all doubt the danger of ever becoming dependent upon a distant oil supply source, or one subject to interruption by outside political forces.

Only a healthy domestic industry will be sufficiently active and competitive to assure the U. S. that an adequate at-home oil supply will be available when the next national emergency strikes.

Warren L. Baker

New Prices Needed to Help Assure Oil for Emergencies

- **Prices of oil are still low despite recent increases. The consumer still gets bargains in petroleum products.**
- **Revisions were necessary to cover increased costs and give fair return on oil investments.**
- **New prices are essential to vigorous development of vitally needed domestic oil reserves.**
- **Prior to price changes, dangerous dependence on foreign oil was threatened.**
- **Suez crisis emphasized importance of domestic oil to security of U. S. and its allies.**

By HINES H. BAKER
President, Humble Oil & Refining Company
Houston

PRICES OF CRUDE OIL, gasoline and petroleum products generally are relatively low, despite the increases of early 1957. They are low considering the increases in costs of labor and materials used by the petroleum industry. They are low in terms of the earnings and purchasing power of consumers. They are low in that the rate of return on domestic petroleum investments has been declining and is now less than in manufacturing industries generally. Finally and most important, they are low in that they have not encouraged enough exploration to maintain the ratio of proved reserves to domestic demand.

In the light of these facts, Humble Oil & Refining Company in late 1956 concluded that an increase in prices was long delayed and that as a buyer and seller of crude oil and gasoline, it should seek to adjust its prices upward. On the basis of its knowledge of conditions in the domestic petroleum industry, the company believed that its action in January 1957 increasing prices was a step in the right direction, both in an immediate effort to supply the present extraordinary demand and for the long run, and that it would prove to be in the national interest. This same view still is held.

On January 3, 1957, Humble Oil & Refining Company increased its posted prices for crude oil in Texas by an average of about 35 cents a barrel. In announcing that increase, the company issued a statement setting forth the basic reasons for its action. The statement was as follows:

"The immediate cause of this price change is the sharp increase in demand for domestic crude oil, particularly in Texas, that has developed since the flow of Middle East crude oil to Europe and the East Coast was drastically curtailed by recent events. Humble has been unable to secure its requirements at former prices.

"An important cause of a more basic nature is the substantial rise in unit costs since the previous general increase in crude oil prices in June, 1953. During this period of more than 3½ years crude oil prices generally have remained constant although wages and salaries, costs of materials purchased, and the investment required for the same amount of production have all increased greatly. In view of these various circumstances, Humble has advanced prices by an amount that should help it to secure additional supplies which it has been unable to purchase to meet unusually heavy demands, and should also tend to encourage the rate of domestic exploration and development of new oil resources desirable for reasons of national security."

Beyond that statement of basic factors, further information is here supplied.

Crude Price Changes in 1957. Humble Oil & Refining Company concluded at the end of 1956 that a higher level of prices paid by it to those from whom it purchases oil was immediately appropriate and also in the right direction for the long run. This conclusion was based on the company's immediate needs for more crude oil, higher costs and narrowing profit margins in the industry, the need for expanded exploration and development, and the long time required to realize results from increased development.

On January 3, 1957, Humble raised prices on the crude oil it handled by amounts varying generally from 25 to 45 cents a barrel, depending on relative values, and averaging about 35 cents on the company's total volume. The amount of the increase was a matter of judgment. The general increase made seemed the minimum warranted by the circumstances.

The level of general market prices

is determined by evaluation of buyers and sellers as to current and prospective conditions of supply and demand. Some trial-and-error is involved in determination of a new level of market prices following initiation of price changes. At times in the past when others initiated price increases that in Humble's judgment were not warranted by economic circumstances, Humble has resisted making changes. In 1947 Humble's judgment to resist an upward movement in prices proved wrong, and the company had to meet a higher level in order to secure necessary supplies for its customers. In 1948 Humble resisted another price increase, and in that case its judgment proved right, as borne out by the fact that the companies initiating the changes finally had to drop back to the general market level. If Humble's judgment on crude oil prices in January 1957 had been in error, other companies would not have changed their prices, and Humble would have taken action to move back toward the established market level.

Humble posted price increases varying among grades of crude oil in accordance with its interpretation of their relative values. Other companies made changes which were smaller in some cases and larger in others than those posted by Humble. In West Texas, for example, Humble increased its price by 25 cents a barrel, but a number of companies raised prices by 35 cents a barrel and one raised 30 cents. Subsequently over a period of time, these purchasers dropped back to a 25 cent increase. For the Anahuac and Sweden grades, Humble posted an increase of 45 cents, but others raised comparable crudes only 35 or 40 cents. Humble found that market conditions established a lower price than it had posted; and it adjusted its prices for these grades downward by 5 cents a barrel on February 1, 1957.

Adjustments of the type described are part of the process of finding the general market level. By the end of January, it appeared that the general market level for crude oil prices had increased about 25 cents a barrel in West Texas and the Mid-Continent areas, about 35 cents in East Texas, and about 40 cents along the Gulf Coast, with an average increase of about 30 cents in Texas and 25 cents in the Mid-Continent producing area.

Suez Effect on Humble. In October 1956, crude oil production in Texas was 2,924,000 barrels daily. In the Texas market, Humble purchased 366,000 barrels daily from others and had available a total supply including net production run from its leases of 568,000 barrels daily. Its refinery runs were 241,000 barrels daily, of which about 150,000 was purchased oil. In addition Humble had some net production sold at leases to others in Texas and other states.

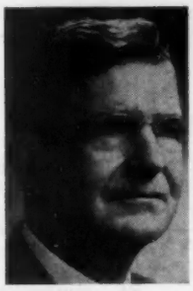
Early in November the flow of crude oil from the Middle East to Europe and to the East Coast of the U. S. was drastically reduced by the closing of the Suez Canal and the disruption of pipe line movements from Iraq to the Eastern Mediterranean. On November 2, 1956, Humble was advised by affiliates of Standard Oil Company (N. J.), its largest customers, of an additional emergency export requirement at the rate of 5 to 8 million barrels a month for November and December. This constituted an increase of more than 50 percent in the amounts customers wished to purchase from Humble. The company also was advised that substantial emergency requirements might continue for an indefinite period, depending upon the restoration of normal movements from the Middle East to Europe.

Humble was asked to use its best efforts to provide the maximum possible quantity for export to Europe, although it does not normally supply oil for Europe. It proceeded immediately to make available all the supplies it could from its receipts and inventories and to purchase additional supplies from others. In November and December, Humble was able to supply for export to Europe 7,611,000 barrels, which was less than its customers could have taken if the company had been able to make more available. It was able to do this only by extraordinary spot purchases of 3,605,000 barrels from other companies and by drawing on its inventories. The company's inventories at coastal terminals for tanker loading were virtually exhausted by the end of December, so that its ability to meet requirements in 1957 depended on the supplies that it could secure from current production and from spot purchases from other companies.

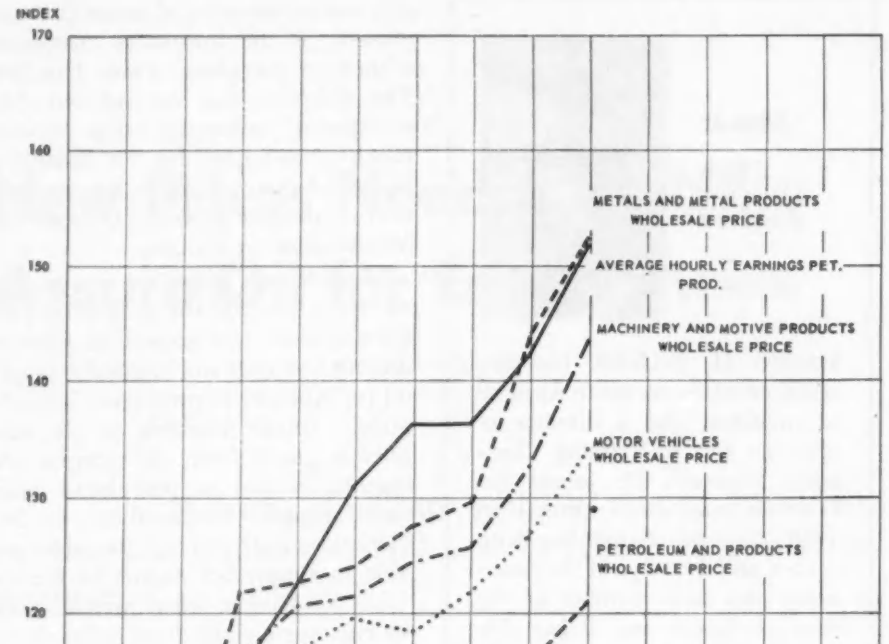
Humble representatives made appearances before the Railroad Commission of Texas presenting vigorously the company's additional requirements for crude oil in November, December and January. There were other purchasers, however, who apparently did not need or want additional supplies of crude oil, as indicated by their nominations. After weighing evidence on market demand and other factors, as provided for by the Texas conservation statutes, the Railroad Commission set allowable production in December and January at only slightly higher levels than in November. After crude oil inventories showed a substantial decline, it allowed a further increase of over 100,000 barrels daily for February. The allowable production established by the commission did not make available to Humble as much oil as it wanted. This is said as a fact and not as a criticism of the commission, because it had many factors to consider in the performance of its legal duties.

Humble repeatedly sought to buy

About the Author



HINES H. BAKER has announced plans to retire April 29 as president and a director of Humble Oil & Refining Company, Houston. He joined the Humble law department in 1919 after practicing law with Foster and Hardwicke in Beaumont and as a member of the firm of Baker and Baker. He has been a director of Humble since 1937, was vice president from 1941 to 1945, served as executive vice president from 1945 to 1948 and was elected president in 1948. Baker was graduated from The University of Texas with B.A. and LL.B. degrees and was elected to Phi Beta Kappa. He has been continuously active in civic and cultural affairs and has taken a leading role in various professional organizations.



Source: Bureau of Labor Statistics reports on wholesale prices and hourly earnings.

FIGURE 1—Prices of petroleum products and major costs of the petroleum industry at the end of the years 1947 - 1956 (1947 - 49 = 100).

crude oil from other companies, but was unable to secure oil in the quantities needed. In December it bought outright what oil was available, including 2,282,000 barrels it was able to buy from inventories held by several companies only by agreeing to make available an equivalent amount of oil in 1957 at the same prices they charged Humble. Because of the urgent needs of its customers, Humble bought crude oil on this basis, thereby taking the risk of having to buy oil at higher prices in 1957 to take the place of oil exported to Europe at lower prices. By the end of the year Humble was no longer able to secure additional supplies from other companies at prevailing prices or even through special arrangements such as described.

As a result of the preceding circumstances, Humble's prospective receipts of crude oil at the end of 1956 were such that it could plan to supply for export only 600,000 barrels in January against a minimum export demand of 5,500,000 barrels. Humble was advised by its principal customers that unless additional supplies could be made available it would be necessary to divert tankers from the Gulf Coast to the Middle East. This action would reduce the ability of tankers to deliver oil to Europe and would increase costs because of the distance and cost of the trip around Africa.

Efforts to make available additional oil on the Gulf Coast appeared highly desirable in the situation that existed at the end of December. Humble concluded that the only possible method remaining by which it might secure such supplies was to raise its price for crude oil. From its knowledge of the basic economic situation in the domestic petroleum producing industry and of the implications of the crisis in the Middle East for long-term domestic petroleum requirements, Humble decided that a higher level of posted prices at which it buys and on the basis of which it sells crude oil was required both immediately and for the long run. The company hoped that this action would make available some additional supplies for emergency shipments to Europe. It believed also that such a move was consistent with the desirable long-term objective of seeking to assure for Humble a greater potential source of domestic supplies for its customers in the long run.

Domestic Oil Is Vital. The Suez crisis emphasized the hazards involved in use of oil from the Middle East. It demonstrated dramatically that future supplies of domestic oil are even more important for the security of the U. S. and its allies than had been generally realized. In Humble's judgment the crisis meant that proved domestic reserves of petroleum should grow at least as rapidly as domestic demand, in order to avoid the risk of increasing dependence on foreign oil. By this criterion, the level of prices that had prevailed in recent years was inadequate.

Although drilling has continued to increase, proved domestic reserves of crude oil have increased in recent years at a considerably slower rate than domestic demand. In 1954 and 1955, they increased by only about 1.1 million barrels, or an average annual rate of only 1.8 percent. Domestic demand has continued to grow at an average rate in excess of 4 percent annually. Domestic productive capacity has been rising at a satisfactory rate relative to normal requirements. But there has been a deterioration in the basic relationship of known reserves to demand. The trend in this relationship, which is the basic measure of the adequacy of domestic exploration in terms of future requirements, is shown for the period 1941-1956 in Table 1.

The tabulation shows that proved domestic petroleum reserves are now

less adequate in relation to domestic demand than at the beginning or end of World War II. In 1956 proved domestic petroleum reserves were only 11 times the annual rate of domestic demand. This ratio of reserves to demand is considerably lower than in the past and less than is desirable. This declining ratio reflects the lack of incentives for domestic exploration and development of new resources.

Factors Affecting Crude Prices. Against this background of recent developments, examine the broader considerations affecting crude oil prices.

Two important facts stand out:

1. Petroleum prices have not kept pace with the increase in costs.

2. The rate of earnings on domestic petroleum operations has been declining and is relatively lower than it should be as compared with other industries, considering the risks involved.

Oil Prices Behind Rising Costs. Since 1947 there have been only two general increases in crude oil prices. Crude oil prices in the U. S. averaged $2.60 in 1948. They declined slightly in 1949-1950, and did not increase generally until 1953. An advance of about 25 cents in 1953 raised the average price to about $2.77 a barrel. This advance was much less than the change that had occurred in costs in the preceding five years. The second general advance followed the increase Humble made in January, 1957, and appears to have raised average industry prices to about $3.07 per barrel, compared with $2.60 at the end of 1947, an increase of 18 percent.

The wholesale price index for petroleum and products as of January 29, 1957, following the recent price increase, was 29 percent higher than in the base period 1947-1949, according to information released by the Bureau of Labor Statistics. By comparison, the principal cost items in petroleum producing operations have shown increases of 40 to 60 percent. Wage rates in petroleum production have increased by 52 percent from an average hourly rate of $1.64 in 1947-1949 to $2.49 at the end of 1956. The wholesale price indexes at the end of 1956 showed increases of 63 percent for iron and steel, 52 percent for metal and metal products, and 43 percent in machinery and motive products, as shown in Table 2 and Figure 1. The prices of these commodities are major elements of cost in petroleum operations.

The changes in two of the oil industry's principal cost items, wages and steel, can be illustrated by the experience since the general crude oil price increase in June, 1953. Wage rates in petroleum operations increased 4 percent in 1953, 4 percent in 1955, and 6 percent in 1956, making a cumulative increase of more than 14 percent. The price of J-55 steel casing for new wells increased 4.5 percent in June, 1953, 3.1 percent in July, 1954, 7.0 percent in July, 1955, 7.7 percent in July, 1956, and 3.3 percent recently, making a cumulative increase of about 28 percent since May, 1953. The price of this casing is now $198.25 a ton, compared with $154.65 at the end of

Table 1—Relation of Proved Reserves to Domestic Demand in the U. S.

	January 1 Proved Reserves Million Barrels			Domestic Demand	Ratio of Proved Petroleum Reserves to Domestic Demand
	Crude Oil	Nat. Gas Liquids	Total	Million Barrels	Total Liquids
1941	18,300	2,850	21,150	1,486	14.2
1946	19,942	3,078	23,020	1,793	12.8
1951	25,268	4,268	29,536	2,574	11.5
1956	30,012	5,438	35,450	3,228	11.0

Source: American Petroleum Institute (reserves) and Bureau of Mines (demand).

Table 2—Wholesale Commodity Price Indexes, 1947-1949 = 100, for Petroleum and Other Major Groups

	Year 1948	Year 1953	Dec. 1956	Est. Jan. 1957
Petroleum and Products	111.7	112.7	120.9	129.3
Major Groups Particularly Affecting Petroleum Costs				
Iron and Steel	104.3	131.3	163.3	N. A.
Metal and Metal Products	103.9	126.9	152.4	N. A.
Machinery and Motive Products	100.9	123.0	143.5	N. A.

Source: Bureau of Labor Statistics

Table 3—Net Income and Net Assets* of Eight Important Oil Companies With Relatively Large Production and Without Substantial Income From Foreign Operations.

	1947	1948	1949	1950	1951	1952	1953	1954	1955	Est. 1956
Net Income—Million $										
Humble	124.1	186.1	120.5	129.4	169.5	145.3	164.3	146.3	175.0	178.9
Std. (Ind.)	94.9	140.1	102.7	123.6	148.7	120.0	124.8	117.2	157.1	167.8
Phillips	40.9	72.6	44.5	51.6	73.7	75.3	76.8	76.2	95.2	95.2
Continental	31.4	54.2	36.1	42.4	41.3	38.1	40.9	41.7	46.4	51.8
Ohio	29.2	49.3	33.7	37.3	41.7	39.4	43.5	38.2	41.3	41.2
Skelly	21.1	39.8	26.2	28.5	31.1	28.0	31.3	29.5	32.2	33.0
Shell	61.4	113.8	80.4	94.2	97.0	90.9	115.4	121.1	125.5	135.8
Amerada	14.9	22.6	14.4	15.4	16.3	15.9	18.4	19.8	25.4	28.7
Total	417.9	678.5	458.5	522.4	619.3	552.9	615.4	590.0	698.1	732.4
Net Assets* (End of Period)—Million $										
Humble	559.4	673.5	722.1	779.6	865.2	928.5	1008.6	1072.9	1163.9	1257.5
Std. (Ind.)	924.9	1018.7	1083.3	1165.7	1271.6	1356.8	1436.9	1574.2	1701.1	1822.6
Phillips	332.7	388.1	416.0	448.5	568.6	613.5	653.7	693.2	901.1	941.4
Continental	168.6	210.0	266.8	246.7	263.7	277.9	293.5	310.1	329.2	351.2
Ohio	139.6	173.8	192.4	212.0	234.0	253.7	275.9	294.4	315.3	335.5
Skelly	92.6	127.8	147.8	169.9	192.5	211.4	233.4	253.1	275.0	297.7
Shell	306.9	377.9	413.9	489.4	546.0	596.5	671.3	740.9	814.9	890.1
Amerada	42.6	55.8	62.3	68.2	75.1	81.5	90.5	100.8	115.1	131.2
8 Cos.	2567.3	3025.6	3264.6	3580.0	4016.7	4319.8	4664.8	5039.6	5615.6	6027.2
Rate of Return on Average Net Assets*—Per Cent										
8 Companies	17.39	24.26	14.58	15.26	16.30	13.26	13.70	12.16	13.10	12.60

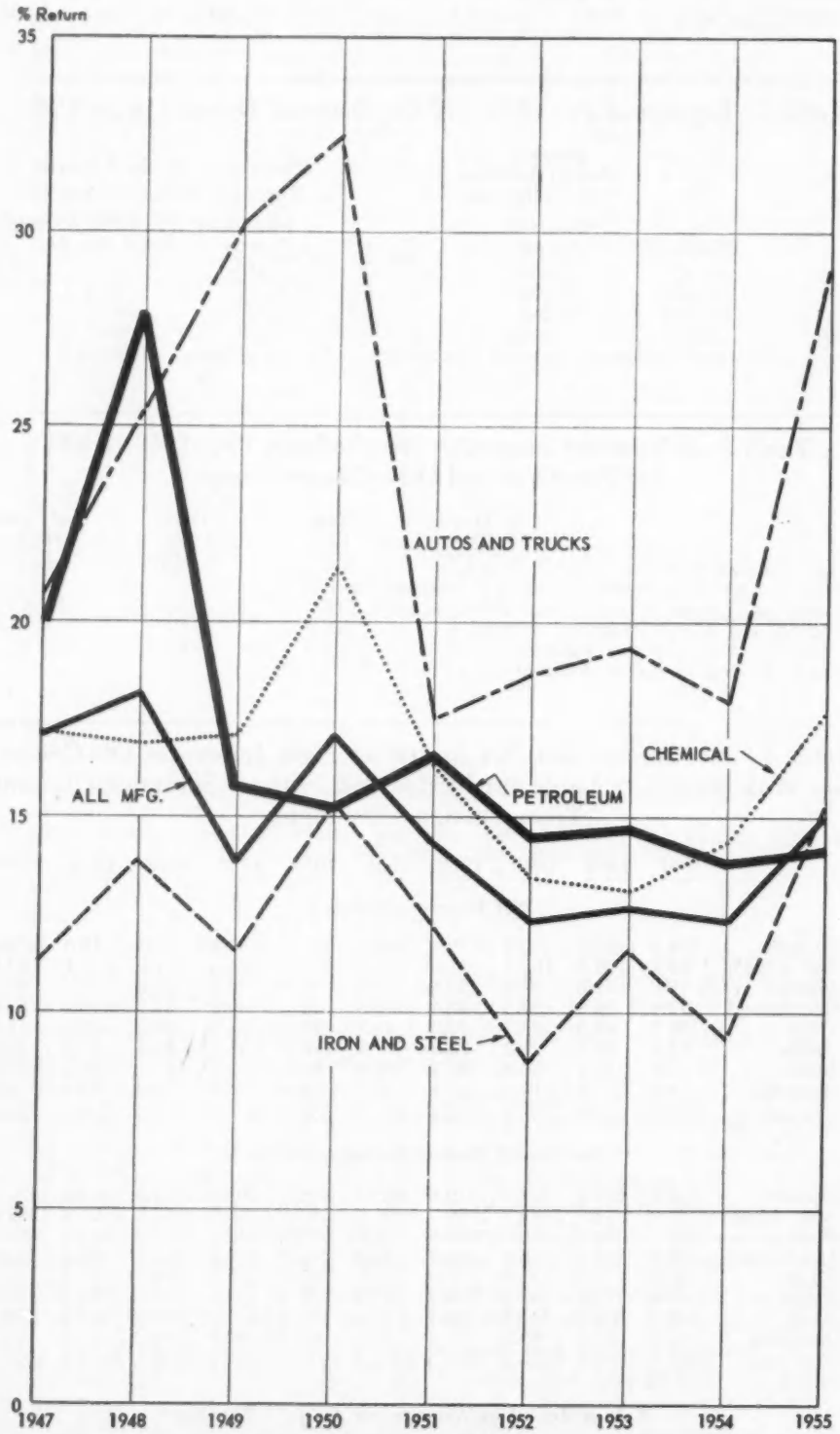
* Shareholders' Investment

Source: Annual reports and preliminary statements for 1956.

May, 1953. While these numerous wage and price increases were taking place, crude oil prices generally remained the same during the 3½-year period prior to the recent advance.

In addition to the effect of the large increases in costs of materials and labor, the petroleum industry has had to contend with other factors adding greatly to its costs. The increasing depth of new wells, the increasing proportion of dry holes, and the rising volume of work in expensive areas, such as offshore drilling, all contribute to rising unit costs. Constant improvement in technology and investment in more efficient equipment have been offsetting factors that have helped to make the advance in wholesale prices of petroleum and products relatively smaller than that of many other commodities.

The preceding factors have operated to increase industry costs on the order of 10 to 15 cents a barrel annually. This would indicate an increase in costs of 35 to 50 cents a barrel since the last general advance in crude oil prices in June, 1953. This consideration was a major factor in Humble's decision as to the amount of the price increase it made in January, 1957.



* *Industries with book net assets over $5 billion on January 1, 1955.*
Source: First National City Bank of New York Monthly Letter.

FIGURE 2—Net return on net assets of leading corporations in selected industries,* 1947-1955.

Return on Assets Lower. The fact that costs for petroleum have risen more than prices has meant decreasing profit margins and a lower rate of return on investments in domestic petroleum operations.

Despite the popular impression of greatly increased profits in the petroleum industry, Humble's studies indicate that the rate of return on investments in domestic petroleum operations has been declining during the past 10 years. Table 3 shows the net income and net assets of eight important domestic oil companies that are relatively large producers without substantial income from foreign operations. It shows that the total investment by the eight domestic companies listed had approximately doubled between 1948 and the end of 1956, whereas their net income was only 40 percent higher in 1956 than the average in 1947-1949. Consequently, the rate of return on investment had declined to a level that falls below the average for manufacturing corporations generally, although the rate of return should be higher because of the greater risks in oil producing operations.

Table 4 shows the return on net assets of leading corporations by major industrial groups. It indicates a return of 14.2 percent on petroleum producing and refining, including the high return on large foreign investments, compared with 15 percent for corporations engaged in manufacturing generally. It should also be noted that the rate of return in 1955 in a number of industries, such as chemicals, cement, iron and steel, automobiles, and aircraft, was higher than in petroleum operations. The return for the petroleum industry in 1954 and

1955 was at its lowest postwar level. But the 1955 rate of return in manufacturing generally and in several major industries was at the highest level in five years. (See Table 5 and Figure 2.)

Humble's experience illustrates the decreasing rate of return on domestic petroleum investments. Its net income in 1956 of $179,000,000 was only 9 percent more than in 1953 and actually less than the income eight years before in 1948. By comparison, the company's investment has increased approximately 25 percent since the end of 1953 and 87 percent since the end of 1948. Humble's rate of return in 1956 was less than 15 percent on its average net investment, and much less than that on recent investments.

It is well to note that average returns on total petroleum investments substantially overstate the rate of return being realized on *current* investments because of the much higher level of costs now being incurred than was the case for reserves acquired in earlier years. It cannot be expected that money will be reinvested in exploration and development in order even to replace current production, much less to expand reserves, unless the return on current investments appears sufficiently attractive to compensate for the risks taken.

Gasoline Price Changes. As a direct marketer of gasoline in Texas and New Mexico, Humble had to decide what part of the increase in cost of crude oil it should seek to recover from gasoline. It had to consider the situation of its refinery and also the increase in prices paid to several inland refineries for gasoline bought from them to supply part of its market.

Humble estimated that the average price of the crude oil used at its refinery increased about 35 cents a barrel. The output of products from a barrel of crude oil is about 40 gallons after allowing for refinery use and losses. In order for the company to realize in its refining operations the higher price of the crude oil used, whether from its own production or from purchases, it was necessary to realize nearly one cent a gallon more on all refined products. Therefore, Humble decided to raise prices at which it sells gasoline to service stations by one cent a gallon. The inland

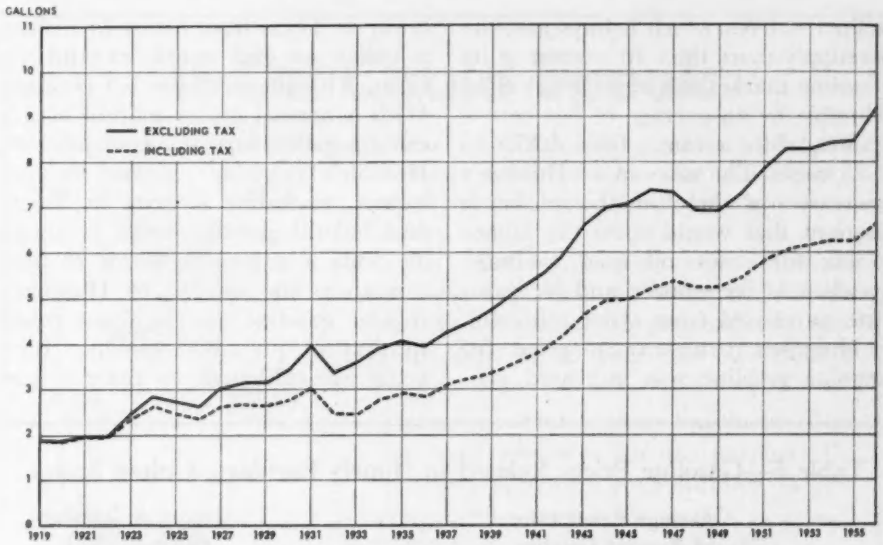


FIGURE 3—Gallons of regular gasoline purchased with an hour's pay in manufacturing.

Table 4—Percent Return on Net Assets of Leading Corporations in Selected Industrial Groups.

No. of Cos.	Industrial Group	1947	1948	1949	1950	1951	1952	1953	1954	1955
26	Tires, Rubber Products	16.0	13.4	8.7	15.9	16.4	13.4	14.0	11.9	15.1
27	Lumber	33.1	23.1	10.7	17.0	16.0	11.4	10.3	9.7	14.2
76	Paper and Allied Products	23.7	19.6	12.8	17.1	16.1	12.0	12.2	12.4	13.8
61	Chemical Products	17.2	16.9	17.1	21.4	16.3	13.5	13.2	14.4	17.7
24	Drugs and Medicines	20.7	21.3	16.2	21.9	19.9	14.6	13.8	14.8	18.3
92	Petroleum Production and Refining	19.9	27.9	15.7	15.2	16.6	14.5	14.7	13.8	14.2
32	Cement	11.5	17.0	18.8	17.8	14.5	14.3	15.0	18.6	20.3
56	Iron and Steel	11.3	13.9	11.6	15.3	12.3	8.8	11.6	9.4	15.2
11	Agricultural Implements	11.0	13.6	15.8	15.7	11.9	10.9	8.1	6.9	8.8
75	Building, Heating, Plumbing Equipment	19.6	20.1	12.6	17.8	13.8	10.9	10.2	9.8	11.5
87	Electrical Equipment, Radio and TV	19.9	20.3	17.3	22.5	16.0	14.8	14.9	13.9	12.8
157	Machinery	17.0	18.6	12.4	14.2	14.9	14.1	12.9	11.7	11.6
29	Office Equipment	—	24.3	18.4	19.3	16.9	14.3	13.2	14.7	16.9
41	Nonferrous Metals	14.8	15.3	8.0	14.5	13.5	11.5	11.0	10.8	16.7
49	Instruments, Photo Goods	—	—	—	—	—	—	13.5	16.9	17.7
15	Autos and Trucks	20.7	25.4	30.2	32.5	17.6	18.7	19.4	18.0	29.1
41	Aircraft and Parts	—6.0	2.9	8.2	14.3	9.1	17.9	20.1	27.1	24.7
1,765	Total Manufacturing	17.1	18.2	13.9	17.1	14.4	12.3	12.7	12.3	15.0
21	Coal Mining	11.4	16.1	7.2	8.7	9.0	6.6	3.5	1.7	5.6
36	Metal Mining	13.0	11.4	7.2	14.7	14.3	10.4	8.8	10.0	13.7
11	Other Mining, Quarrying	24.3	24.9	29.4	29.8	25.8	24.2	24.4	26.8	26.2
68	Total Mining, Quarrying	16.0	20.5	12.0	13.2	13.0	10.1	7.9	8.2	11.9

Source: First National City Bank of New York Monthly Letter.

Table 5—Rate of Return on Net Assets of Leading Corporations By Major Industries, 1951-1955

	Per Cent Return					Change
	1951	1952	1953	1954	1955	1951-1955
Petroleum Prod. & Ref.	16.6	14.5	14.7	13.8	14.2	— 2.4
All Manufacturing	14.4	12.3	12.7	12.3	15.0	+ 0.6
Iron and Steel	12.3	8.8	11.6	9.4	15.2	+ 2.9
Chemical Products	16.3	13.5	13.2	14.4	17.7	+ 1.4
Autos and Trucks	17.6	18.7	19.4	18.0	29.1	+11.5

Source: First National City Bank of New York Monthly Letter.

refineries from which it buys gasoline to supply more than 30 percent of its gasoline market raised their prices to Humble by an average of one cent a gallon, with a range from 0.875 to 1.25 cents. The amount of Humble's increase was therefore the minimum amount that would cover the higher prices for crude oil used to make gasoline at its refinery and for gasoline purchased from other refineries.

Humble's tankwagon price for regular gasoline was increased generally in Texas from about 15.5 cents a gallon to 16.5 cents, excluding taxes. This increase was 6.5 percent. With a normal dealer margin of 5.5 cents a gallon, the delivered price of Humble's regular gasoline to customers, excluding 8 cents in Texas and federal gasoline taxes, is about 22 cents a gallon. In terms of performance, the quality of Humble's regular gasoline now is about equal to that of premium gasoline three years ago, although its price is one cent less than premium gasoline was in 1954.

The American Petroleum Institute reports that the average retail price of gasoline, excluding taxes, in 50 cities was 21.61 cents a gallon in 1956. If this price were to advance generally by one cent a gallon to 22.61 cents, it would still be only 1.33 cents, or 6 percent, above the average price in 1953. Even with such an increase, gasoline continues to be a better buy than in the past. The average hourly earnings in all manufacturing were reported to be $2.05 at the end of 1956, compared with $1.77 in June, 1953, an increase of over 15 percent. With the pay from an hour's work, the average employe in manufacturing can buy nine gallons of gasoline, excluding taxes, compared with 8.3 gallons in 1953. Even taking into account taxes, which have increased from an average of 7.4 cents a gallon in 1953 to 8.9 cents a gallon currently, the pay for an hour's work in manufacturing will still buy 6.6 gallons of gasoline now compared with 6.2 in 1953. In fact, the pay for an hour's work buys more gasoline than in any prior year, as shown by Table 6 and Figure 3. Furthermore, the quality of gasoline today is far superior to that in earlier years.

The question has been raised why gasoline prices should increase at all in view of a current level of inventories considerably higher than a year ago. The level of inventories is only one factor affecting prices. Costs and the current relation of demand and new production, taking into account seasonal factors, are far more important influences on price than inventories.

The seasonal nature of the demand for gasoline and heating oil means that gasoline stocks normally increase substantially in winter and decrease in summer, while heating oil stocks decrease in winter and increase in summer. Industry operations geared to this fact, including the accumulation of seasonal inventories, allow the industry to meet consumer requirements at the lowest possible cost. Furthermore, as demand increases it is necessary to carry larger total inventories to fill additional lines and tanks in order to avoid any risk of shortages. Surveys by the National Petroleum Council at the request of the government have shown that about

Table 6—Gasoline Prices Related to Hourly Earnings, United States.

	Average Retail Price of Regular Gasoline at 50 Cities (Per Gallon)		Hourly Earnings in	Gallons of Gasoline Purchased with an Hour's Pay in Manufacturing	
	Excl. Tax	Incl. Tax	Manufacturing	Excl. Tax	Incl. Tax
1919	$0.2541	$0.2547	$0.477	1.88	1.87
1920	0.2974	0.2983	0.555	1.87	1.86
1921	0.2611	0.2631	0.515	1.97	1.96
1922	0.2482	0.2520	0.487	1.96	1.93
1923	0.2106	0.2197	0.522	2.48	2.38
1924	0.1946	0.2094	0.547	2.81	2.61
1925	0.2009	0.2220	0.547	2.72	2.46
1926	0.2097	0.2338	0.548	2.61	2.34
1927	0.1828	0.2109	0.550	3.01	2.61
1928	0.1790	0.2094	0.562	3.14	2.68
1929	0.1792	0.2142	0.566	3.16	2.64
1930	0.1616	0.1995	0.552	3.42	2.77
1931	0.1298	0.1698	0.515	3.97	3.03
1932	0.1330	0.1793	0.446	3.35	2.49
1933	0.1241	0.1782	0.442	3.56	2.48
1934	0.1364	0.1885	0.532	3.90	2.82
1935	0.1355	0.1884	0.550	4.06	2.92
1936	0.1410	0.1945	0.556	3.94	2.86
1937	0.1459	0.1999	0.624	4.28	3.12
1938	0.1407	0.1951	0.627	4.46	3.21
1939	0.1331	0.1875	0.633	4.76	3.38
1940	0.1275	0.1841	0.661	5.18	3.59
1941	0.1330	0.1923	0.729	5.48	3.79
1942	0.1446	0.2043	0.853	5.90	4.18
1943	0.1456	0.2053	0.961	6.60	4.68
1944	0.1462	0.2059	1.019	6.97	4.95
1945	0.1448	0.2050	1.023	7.06	4.99
1946	0.1469	0.2077	1.086	7.39	5.23
1947	0.1693	0.2311	1.237	7.31	5.35
1948	0.1954	0.2588	1.350	6.91	5.22
1949	0.2027	0.2679	1.401	6.91	5.23
1950	0.2008	0.2676	1.465	7.30	5.47
1951	0.2031	0.2715	1.594	7.85	5.87
1952	0.2024	0.2756	1.673	8.27	6.07
1953	0.2128	0.2869	1.765	8.29	6.15
1954	0.2156	0.2904	1.81	8.40	6.23
1955	0.2142	0.2907	1.81	8.45	6.23
1956 (Est.)	0.2161	0.2989	1.98	9.16	6.62

Source: American Petroleum Institute (gasoline prices) and Bureau of Labor Statistics (hourly earnings)

Table 7—Relation of U. S. Gasoline Demand and Inventories

	1941	1946	1951	1954	1955	1956	1957
Inventories, Jan. 1, Million Barrels	84.4	97.7	116.8	157.9	155.4	165.4	185.8P
Rate of Demand for Year, Thousand Barrels Daily	1,903	2,139	3,102	3,466	3,750	3,873	4,060F
Days' Supply Related to Demand During Year	44.4	45.7	37.7	45.6	41.4	42.7	45.8

Source: Bureau of Mines (demand and inventories) and American Petroleum Institute. P—Preliminary. Inventories as of December 28, 1956. F—Forecast.

36.5 percent of inventories of gasoline and other clean products are required as pipe line fill and in tank bottoms. A substantial part of the available inventory is required for normal operations, with the result that only a relatively small part of the total inventory is available for market.

The figures on inventories of gasoline in relation to demand, shown in Table 7, provide a perspective on the situation in recent years.

The tabulation shows that in terms of days' supply, gasoline inventories are quite close to what they have been in many previous years, such as 1941, 1946, and 1954. Only in a short term perspective of selected recent years do gasoline inventories appear high in terms of demand, and that may be the result of seeking to meet the rapidly increasing demand for distillate which is concentrated largely in the winter months.

Gasoline inventories at the beginning of 1957 were about 20 million barrels or 12 percent higher than a year ago. In Humble's judgment they were higher than necessary for this time of year, but probably by not more than three to five days' supply in terms of the average rate of consumption estimated by the Bureau of Mines for 1957. In this light, the level of gasoline inventories at the beginning of 1957 was not such a burden on the market as to preclude the prospect of reflecting the higher price of raw materials in the price of gasoline. Furthermore, the seasonal addition to gasoline inventories in January was smaller than in any of the four preceding years. In other words, the current relation of demand to supply was stronger than normal at this time of year. Consequently, gasoline inventories of 196,400,000 barrels on February 1 were only 13,700,000 higher than a year ago, a considerable improvement from a month earlier. With recent adjustments being announced in refinery runs and yields in an effort to supply more oil for Europe, there should be a decline in the level of inventories relative to demand.

ACKNOWLEDGMENT

From a statement presented before the Senate Sub-Committee on Anti-Trust and Monopoly in Washington, D. C., on February 21, 1957.

If Oil Could Speak

If oil could speak it would have many fascinating truths to tell the non-oil public—truths that would win thousands of new friends for the oil industry.

But, oil can't speak—you can. You, as an individual, can win many new friends for the oil industry if you will pass the true facts on to your non-oil industry friends.

Here are some of those true facts. They are being presented for one purpose: To keep you posted on your industry, so you can tell the story oil is unable to relate.

Read these facts. You will find them informative—and interesting.

"If Oil Could Speak" it would tell the American public:

•

- Experience has shown that an average production rate of 9 percent of reserves can be safely maintained. Thus, to produce an additional barrel of oil to satisfy one barrel of new demand, the oil industry must discover 11 barrels of reserves.

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- Cost of finding new crude reserves is increasing. The higher finding costs result from the greater difficulty experienced in finding oil, higher labor and material costs and the fact that the average depth of all new wells drilled is increasing.
  Within the last 15 years the average depth of all new oil wells drilled has increased 38 percent. And the cost of drilling a well increases according to depth as follows: Cost per foot at 4000 feet—$12.50; cost per foot at 8000 feet—$17.00; 12,000 feet—$26.50; 16,000 feet—$153.00.

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- One out of every four development wells are dry holes.

•

- In one year the oil industry risked $3.3 billion on oil exploration and development—and $.5 billion to equip wells and leases for a total of $3.8 billion. This compares with about $8 billion spent in the same year for new plant and equipment by all manufacturing.
  Of the $3.3 billion risked by the oil industry, about $1.8 billion proved to be successful investments and about $1.5 billion was lost. This $1.5 billion lost represented about 25 percent of the gross income realized by operators after payment of royalties. Such odds, even with a tax offset, assuming income to cover them, become a critical factor.

•

- In no other industry is the risk of capital loss so great. Example: In most industries a capital outlay of X dollars will bring to the investor a factory or plant of approximately X value with a known life of utility and productive capacity. In the oil industry a capital outlay of X dollars in a wildcat will result in a dry hole 9 times out of 10—or a million-barrel oil reserve 1 time out of 44—or a 10-million-barrel oil reserve 1 time out of 200.

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Remember: Oil can't speak—you can. Only you can give the non-oil public the true facts about your oil industry.

FIGURE 1

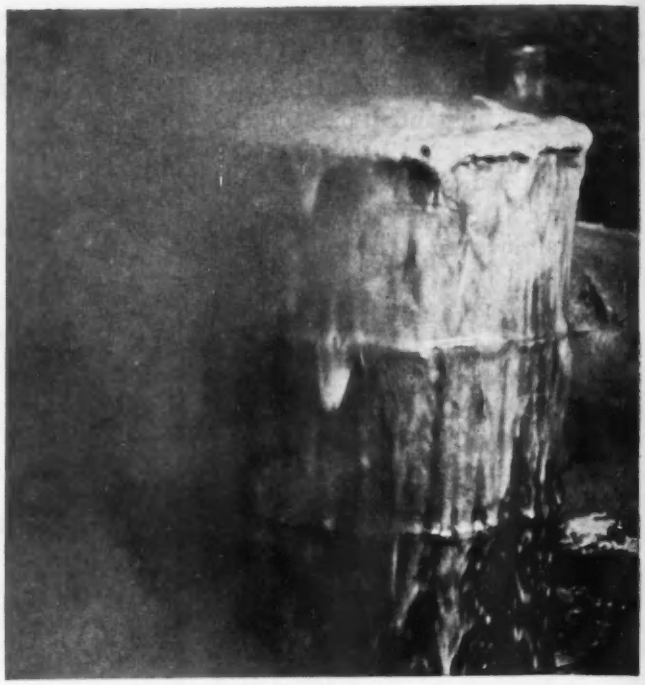


FIGURE 2

Chances of slopover from foam application are smaller in large tanks. The 30-foot diameter tank at left had burned 30 minutes before foam was applied. It did not slop over. The drum at right which contained the same type of crude was allowed to burn only 20 minutes before foam was applied; yet it slopped over.

Safety and Fire Protection—Part III

How to Control Crude Oil Tank Fires

Here are the latest fire control and extinguishment methods including the author's own development—air agitation.

By J. L. RISINGER
Maplewood, N. J.

A LARGE CRUDE OIL tank is located about eight miles from a refinery. Water and foam are available at the farm but no personnel is available except at intervals. The tank farm is large and some of the tanks are of composition or wood roof construction and therefore not lightning proof. The tanks do not have lightning protection.

The farm is not equipped for air agitation. Should a fire occur, it will be from 1 to 2 hours before fire fighters arrive with proper fire fighting equipment. By this time, the heat wave will be from 18 to 30 inches in depth and slopover would occur if the foam were turned on.

Suppose the tank on fire is filled to capacity, or near so. *What can be done?* The following procedures are suggested:

1. The first to arrive must call the superintendent and the refinery.
2. If he arrives over 30 minutes after ignition, he should not turn on the foam but start pumping out.
3. If personnel and facilities are available, start hose streams on shell of tank above liquid level as soon as possible, allowing some water to drain very sparingly over the tank but not enough to cause slopover. Also, paint a stripe of heat detecting paint

on tank from above liquid level to the bottom.

4. When ready to apply foam, reverse and pump in at the highest rate possible until flames come down or for at least three minutes. Even if complete control is not established, the heat wave may be rolled into the quantity of oil so that foam can be applied without slopover.
5. Clear personnel from near shell of tank and start foam. As foam starts, gradually cut down on pumping rate and then cut out pumping entirely. This will allow foam to spread uniformly.
6. If pumping out is through, swing line, lower suction to bottom of tank when pumping out and if suction becomes blocked, pump in to open it up. When pumping in to agitate, raise suction to within about one foot of surface for best results.
7. If pumping-in rate is low and a portable air compressor is used (but not of capacity to do the entire job), use air as auxiliary to pumping in, through the same line, water drawoff or other connection.
8. If tank is equipped with mixers, use them alone if pumping in is not possible. Otherwise, use them as auxiliary to pumping in when foam is ready.
9. If tank has only a few feet of oil in it when ignited, start pumping in as soon as possible to cool down the heat input and assist in saving the tank shell.

Types of Crude Oil Fires—Of first importance to control and extinguishment is knowing the characteristics of the crude oil at a particular location. Simple tests will provide this information.

There are two kinds of crude oil fires: Uncontained and contained oil and gas fires — and the contained oil fire.

Uncontained crude oil fires are fought in the same manner as uncontained product fires, in accordance with the flashpoint of the crude. These running, spewing, or dropping from an elevation low flashpoint fires have to be extinguished by:

- Cutting off the source of flame.
- And/or reducing the air in the vapor-air mixture and throwing it out of the burning mixture ratio.

High flashpoint, uncontained fire can often be extinguished by cooling and thus reducing the vapors below the required volume percentage.

The *contained* fire in which the oil is trapped in a tank or pool is the one in which the crude oil displays its special characteristics of establishing a heat wave and slopping or boiling over.

Some still have the idea that a crude oil tank fire cannot be extinguished. However, extensive tests and research prove that this fire cannot only be controlled, but also extinguished.

It is to be remembered that fire will not continue to burn inside a closed tank. However, coke ignited by iron sulfide might smolder for a considerable time. Therefore, to have a tank fire, part or all of a roof must be removed or ruptured by vapor pressure or an explosion in the vapor space. This enables the entrance of air to support combustion.

The following are various methods of crude tank fire control:

Air Agitation—In the case of high flashpoint crude oil, the air agitation method alone will extinguish the fire if applied before the heat wave is of sufficient depth so that when it is stirred in, the temperature of the oil is raised to above its flashpoint.

Air agitation alone cannot be depended upon to extinguish a low flashpoint crude oil tank fire. In some tests however, crude oils with a low flashpoint but with a vapor pressure below 1 pound per square inch were extinguished by air agitation alone before a heat wave had been established.

Use of Foam Without Slopover—If a large crude oil tank fire can be attacked within twenty to thirty minutes after ignition, depending upon the heat wave rate of the crude oil, there is not much danger of foam causing a slopover. This is a special case in which it is important to know in advance the heat wave rate of the oil.

In a recent test, a 30-foot diameter, 30-foot high tank filled to 25 feet in depth with Mid-Continent crude oil had burned for 30 minutes before the foam was applied. This oil with a 30 percent gasoline content and vapor

Proper Crude Tank Fire Protection Calls for Close Adherence to the Following Seven "Rules-of-Thumb":

1. Before the fire occurs, know the characteristics of the crude oil stored in your tanks and especially those which might become ignited—what facilities are available to control and extinguish the fire.
2. If foam is to be used to extinguish a cone roof crude tank fire:
   a. Apply at required rate before heat wave of slopover depth has been established.
   b. If slopover heat wave depth has been established, cool it out or stir it in before applying foam. It can be stirred in by air agitation, pumped in or a combination of both, at least until the heat wave has reached a one-fourth depth of the oil. It may be best to withhold agitation until just prior to application of foam especially if the crude oil has a low heat wave rate.
3. At all times when fighting a crude oil tank fire, use precautions against burns from slopover or boilover. Plan procedure carefully and deliberately.
4. In smaller tanks where non-water base agent is to be used to extinguish the fire, heat wave characteristics are of no consequence.
5. In the case of small tanks where foam will not arrive for a considerable length of time, plan to extinguish with dry chemicals or other agent that does not have a water base.
6. Make use of heat detecting paint to determine the depth of the heat wave on crude oil tanks that have burned for a period of time from open surfaces before agitating the tank or applying foam.
7. If tank containing crude oil with heat wave establishing characteristics has burned from open surface for a period of thirty minutes, assume that the heat wave is of slopover depth.

FIGURE 3

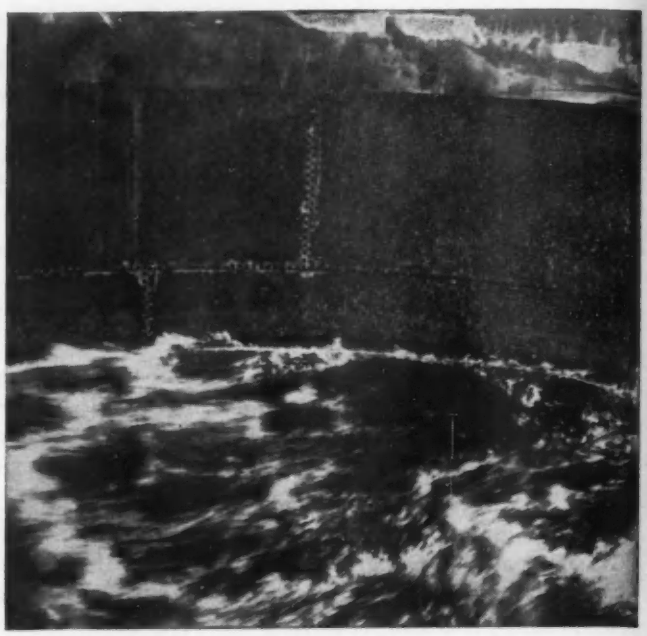


FIGURE 4

WITHOUT AIR AGITATION. Thirty-foot diameter tank at left is shown burning without air agitation. WITH AIR AGITATION. Picture at right was taken from top platform of tank at left, thus showing reduction of flames by agitation when 80 cubic feet of air per minute were injected through line terminating at bottom center of the tank.

pressure of above 5 psi had a rapid burn-off rate, but a heat wave rate of only about 14 inches per hour at first.

Due to the excessive quantity of light ends that had not yet burned off, the temperature of the 7-inch heat wave was calculated to be about 300° F.

Figure 1 shows that when foam was applied, the heat wave did not expand to a greater capacity than the outage of the tank and there was no slopover. Tanks less than 20 feet in diameter, due to the heat input from the shell above liquid level, may establish a slopover heat wave in less time than a larger tank. In drums, crude oils with average heat wave rates will have established a slopover depth heat wave in 20 minutes. (See Figure 2)

If the crude oil tank, regardless of size, has burned for twenty minutes or more, a quick stroke of heat detecting paint will tell how deep the heat wave has penetrated. Nine inches of heat wave in any container provides great possibility of slopover depending upon the nearness of the surface of the oil to the top of the tank and the viscosity of the oil.

It is difficult to establish a safe heat wave depth prior to which foam can be applied without slopover. This would depend upon the height of shell intact above liquid level, viscosity of the oil and the rate of foam application. However, where crude oil tank fires can be attacked with foam within a short time after ignition, they can be extinguished without slopover.

When fighting a crude oil tank fire with foam and if water stream is available, give it a shot at one spot near one side of the shell. If mild slopover occurs, delay application of foam until heat wave can be cooled or dissipated. If foam is applied before an appreciable heat wave is established, air agitation will reduce the flames and the amount of foam required to extinguish the fire (See Figures 3 and 4).

How to Reduce Heat Waves — There are several ways to break up a heat wave of slopover depth and thus prevent a slopover when foam or water is applied.

The old method of cooling out a heat wave before application of foam works part of the time. This method consists of raining water into the heat wave by use of hose nozzle, thus causing a mild slopover which is extinguished with the same hose. This operation is continued until it is considered safe to apply foam. The method takes a long time and usually fails due to impatience and putting foam on too soon.

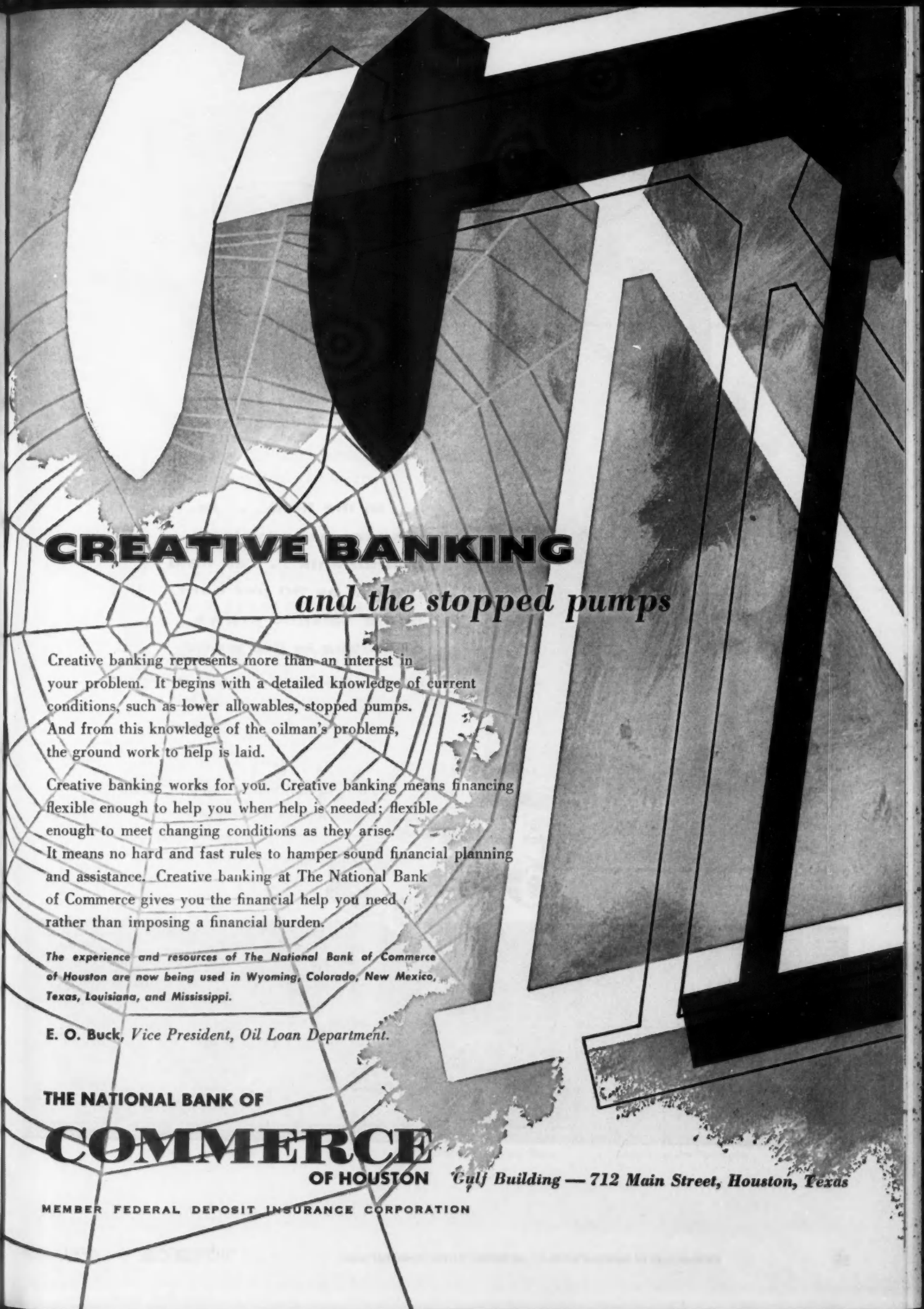
If water is available it should be applied to the shell above the liquid level as soon as possible to prevent it from buckling. Usually, after about ten minutes burning in a tank over 20 feet in diameter and with a 4 or 5-foot free-board, the shell will start to buckle.

Air agitation will reduce the heat wave by stirring it into the quantity of oil. This method is effective up to the time the heat wave has progressed to one-fourth the depth of the oil. Beyond this depth, stirring the heat wave may raise the temperature of the oil above the boiling point of water. In this case (if there is water in the bottom of the tank) a boilover will begin.

If there is no water in the bottom of the tank and the oil temperature is raised above the boiling point of water, a mild slopover may occur when the foam is applied. If good control can be established, the flames will be brought down and less foam required.

In Figure 5 the small crude oil tank has burned to a heat wave depth of approximately one-fourth the depth of the tank so that when foam is applied, the tank slops over. In Figure 6 the same size tank containing the same kind of crude oil has been allowed to burn until the heat wave depth is approximately one-fourth the depth of the oil. But in this case the oil has been agitated with air. When foam is applied no slopover occurs.

Use of Gases and Cold Oil — It is to be kept in mind that in the method of air agitation, air performs



CREATIVE BANKING

and the stopped pumps

Creative banking represents more than an interest in your problem. It begins with a detailed knowledge of current conditions, such as lower allowables, stopped pumps. And from this knowledge of the oilman's problems, the ground work to help is laid.

Creative banking works for you. Creative banking means financing flexible enough to help you when help is needed; flexible enough to meet changing conditions as they arise. It means no hard and fast rules to hamper sound financial planning and assistance. Creative banking at The National Bank of Commerce gives you the financial help you need rather than imposing a financial burden.

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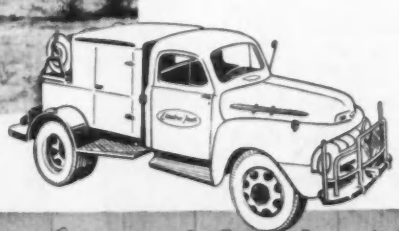
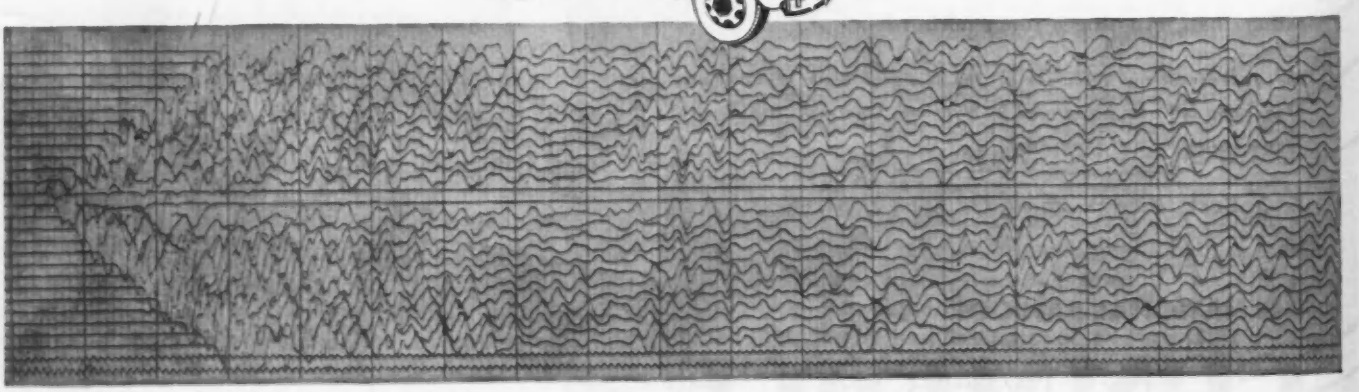
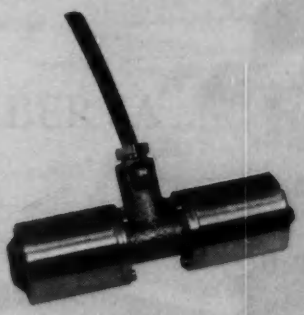
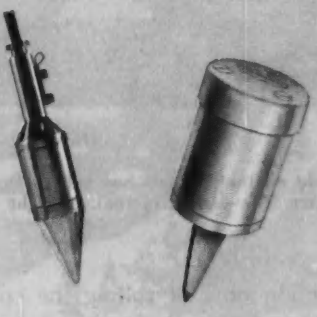




Magnetic Recording Systems



Pressure Detectors



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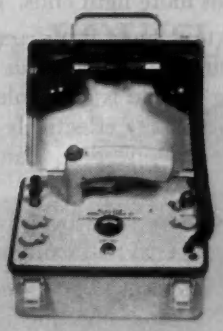

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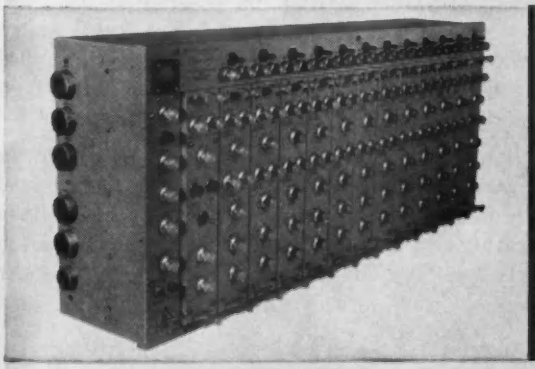
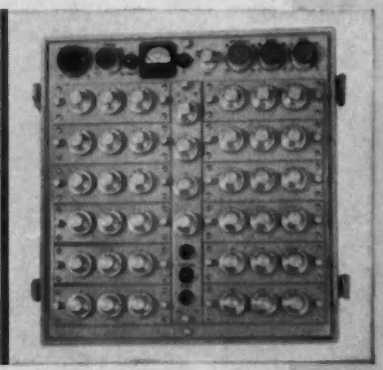
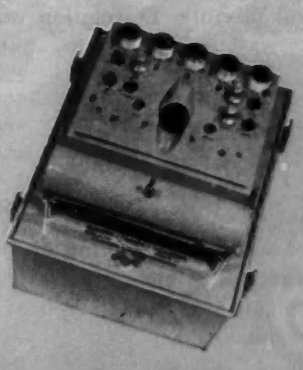


Playback Amplifiers



Reflection-Refraction Amplifiers



Recording Oscillographs

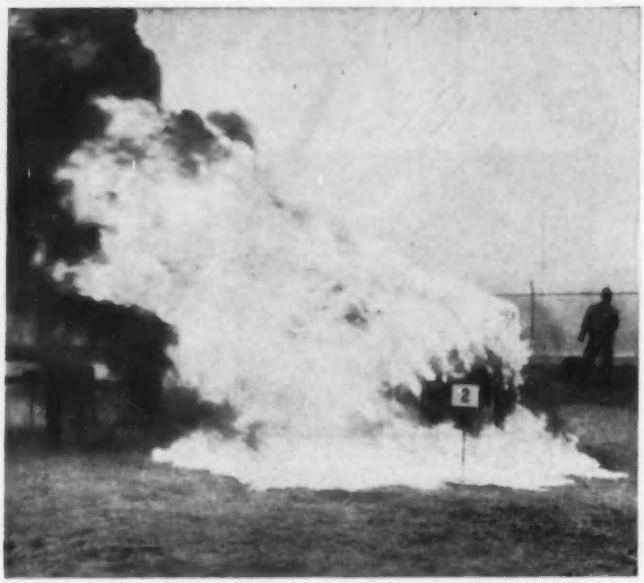


FIGURE 5

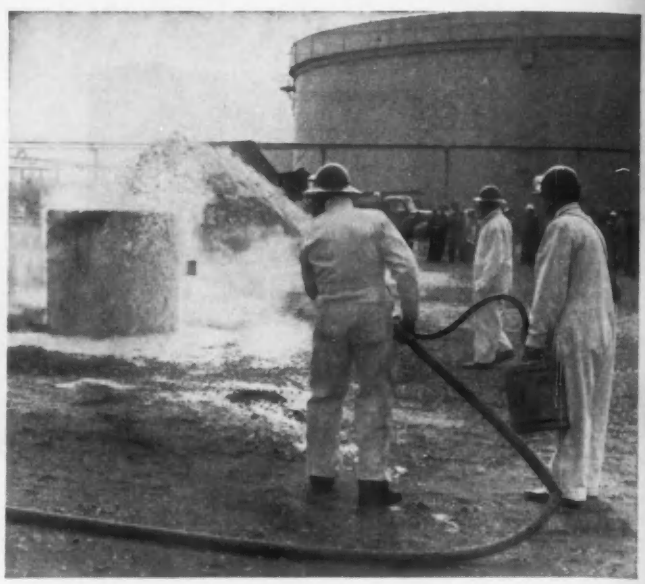


FIGURE 6

Small crude oil tank at left has burned to a heat wave depth of about one-fourth the depth of the tank. When foam was applied the tank slopped over. The same size tank at right which contained the same kind of crude oil and the same depth of heat wave was agitated with air. It did not slop over when foam was applied.

the function only of rolling the cold oil to the surface. Inert gas and even flammable dry gas has been used successfully in tests to perform the same function. Flammable gas, such as light field gas, can be used but caution should be taken not to use a gas that is simply absorbed by the oil and thus adds more light ends.

A few small tests have been run using the pumping of the same oil, circulating and thus stirring the oil. If sufficient pumping in rate is available, cold oil can be rolled to the surface and may effectively stir in and cool a heat wave of greater depth than can be handled with air agitation.

Since but few tests have been made on this method, a detailed description of one example is presented here:

In this test, the tank was 5 feet in diameter and 57 inches high. The tank was filled to within 11 inches of the top with a sour crude mix. This crude had flashpoint below 0° F., an initial boiling point of 146, a vapor pressure above five pounds per square inch and an API gravity of 31.5. Although its final boiling point was 900° F., the quantity of lighter ends was in large proportion to the total mixture. Distillation was as follows:

IPP	—	146 F.
10%	—	228 F.
20%	—	308 F.
30%	—	388 F.
40%	—	488 F.
50%	—	594 F.
59%	—	650 F.

Plans were to burn the tank to a one-fourth depth of heat wave, circulate the oil out of the bottom and back into the tank to agitate the heat wave into the total contents of the oil.

After an hour's burning, it was observed that the burn-off was about ten inches. The heat wave had traveled a distance of 18 inches below the liquid level, or to approximately 3/8 of the depth of the oil. It was calculated that only part of the light ends were removed and therefore the heat wave was about 300° F. temperature so that when stirred in, the temperature of the total quantity of oil would not be over 195° F.

At this time, the circulating pump was started. No attempt was made to greatly reduce the flames, but only to stir in the heat wave. Due to the remaining light ends, foam had to be applied at a fast rate to extinguish the fire. Although there was a small amount of froth at the surface, no slopover occurred.

Temperature Is Important — In addition to facts learned about the new method, the significance of the temperature of the heat wave was emphasized. If the light ends had been completely burned away or the oil had contained but few or none of them, the temperature of the crude oil would have been raised to above the boiling point of water and a slopover would likely have occurred when foam was applied.

There are other unexplored methods of extinguishing crude oil tank fires. For example, suppose there is nothing available except water and the tank has burned for a long time. In this case it may be possible to use hose streams to cool and cause some froth but yet not enough to cause a violent slop. The fire may be extinguished with judicious use of water stream alone. This has been done on small tests.

It is well to consider all of the methods available for extinguishment of crude oil fires. However, in the final analysis, the best way to extinguish fires is to prevent them and the best way to prevent them is to store crude oil in all steel, gas-tight, adequately vented, cone roof tanks or correct floating roof tanks. Then maintain the tanks properly.

If this is done and certain minor precautions are observed with respect to such items as iron sulfide, the problems of fighting crude oil tank fires will become practically nil.

Part 4 will appear in a coming issue of WORLD OIL

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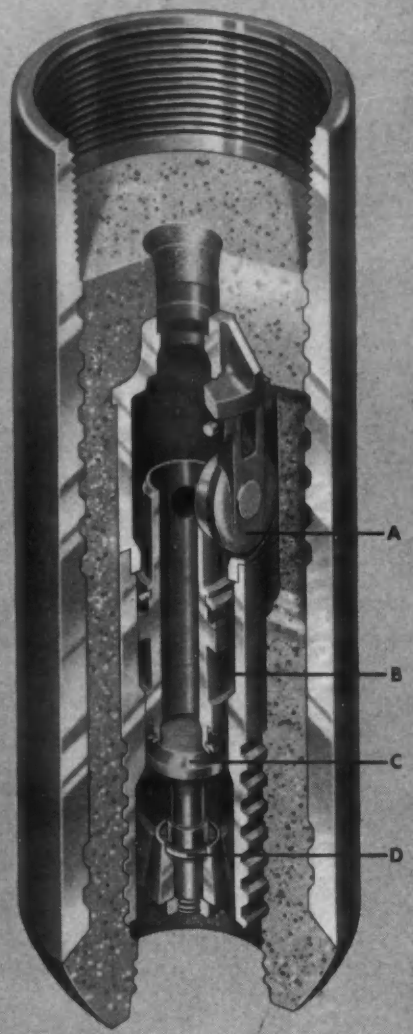


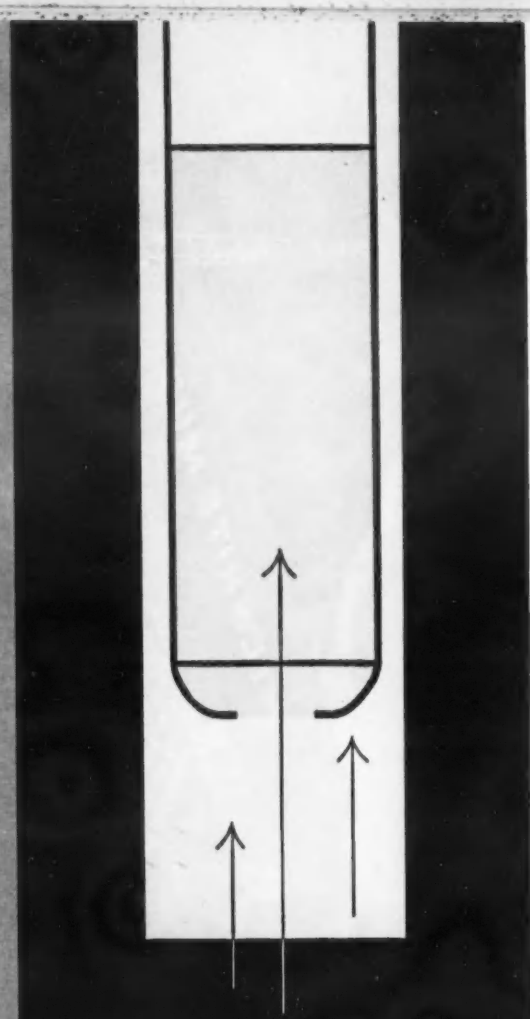
A Flapper Type Back-Pressure Valve activated at option of operator.

B Sleeve Valve } Control rate of flow and volume of fill-up fluid.

C Sleeve Valve Seat }

D When operator shears this Shear Ring (1,000 psi on casing), Flapper Valve is released to form a Back-Pressure Valve for floating or cementing.

Baker DIFFERENTIAL FILL-UP Shoe
Product No. 1081

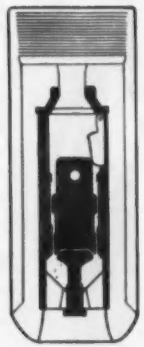


It fills casing from the bottom up

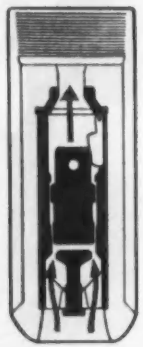
With Baker DIFFERENTIAL FILL-UP Shoes and Collars, casing is filled automatically from the bottom up, *while it is being run*... and because DIFFERENTIAL Equipment contains a Variable Valve *that opens and closes* to synchronize the rate of "fill" with the rate of lowering the casing, maximum reduction of destructive high-pressure surges is obtained.

This "controlled automatic fill" saves up to one-third of running-in time because... (a) time-wasting surface filling of casing is eliminated; and (b) casing can be run in at a faster speed, reducing the possibility of sticking, without causing destructive high-pressure surges. Pressure surges over 5000 psi can be created below casing equipped with floating equipment each time a joint is lowered. Damage caused by these high-pressure surges and the cost of this damage in bad cement jobs, lost circulation, and decreased production is becoming a matter of concern to many operators.

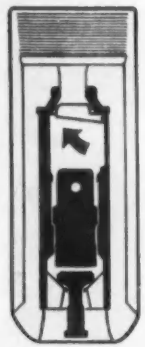
HOW DIFFERENTIAL EQUIPMENT WORKS



RUNNING-IN
Sleeve Valve in closed position



RUNNING-IN
Sleeve Valve in opened position



CEMENTING OR FLOATING
Flapper Valve released

Hydrostatic pressure of the "fill" acts on the upper pressure area of the sleeve valve. Hydrostatic pressure of the fluid in the annulus acts on the lower pressure area of the valve which is 90% of the upper pressure area. It is this differential in area that results in a "fill" of approximately 90% (shoe or collar), or 81% (shoe and collar) with respect to the fluid level of the annulus and gives the equipment its name. The valve opens and closes in accordance with the pressure differential across it to: (1) fill the casing automatically, (2) reduce pressure surges and (3) prevent overfill of the casing.

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BAKER DIFFERENTIAL Fill-Up Equipment

Oil and Gas Reserves Reach New Highs In Both U. S. and Canada During '56

Operators proved up more oil and gas than they produced. But they again had difficulty in developing more new crude than was consumed.

DURING 1956 there were substantial net increases in the U. S. and Canada in proved reserves of crude oil, natural gas liquids, and natural gas. The amounts proved up considerably exceeded the volumes taken from the reservoirs in supplying unprecedented demands for these resources.

These results were revealed by the recently released joint annual reports on reserves by American Petroleum Institute and American Gas Association. The figures on Canada were reported originally by the Canadian Petroleum Association. (See tables.)

U. S. reserves of liquid hydrocarbons increased 886 million barrels in 1956 to a new peak of 36.3 billion barrels. This includes crude oil and natural gas liquids. Operators proved up 3.8 billion barrels of new reserves. But 2.9 billion barrels meanwhile were produced.

U. S. natural gas reserves increased by 14.1 trillion cubic feet to a new peak of 237.8 trillion. That was the greatest annual increase in the 11 years history of AGA reserves estimates. A record volume of 25.0 trillion cubic feet of new reserves was developed. But 10.9 trillion feet were produced in the meantime.

Canada's reserves of crude oil and natural gas liquids increased 372.7 million barrels to a new high of 3.1 billion. Operators developed 544.7 million barrels of new reserves while producing 172.0 million.

Adding Less Crude. The API noted that net results of the crude oil report are on the favorable side again. For constant expansion of reserves is essential to the growth and security of the U. S. But the Institute pointed out that 1956 was the third consecu-

TABLE 1—Estimated Proved U. S. Reserves of Liquid Hydrocarbons, by Years
Sources: Crude, API; Natural Gas Liquids, API and AGA . . . Thousands of Barrels

YEAR	NEW OIL ADDED DURING YEAR: Through Revisions of Previous Estimates and Extensions to Known Fields (1)	Through Discoveries of New Fields and of New Pools in Old Fields (2)	Total Through New Discoveries Extensions and Revisions (Columns 1 + 2) (3)	[1] Production During Year (4)	Estimated Proved Reserves as of End of Year (Column 3-4) (5)	Increase Over Previous Year (6)
[2] Crude Oil & Condensate						
1936	.....	.....	.....	.....	**13,063,400**	.....
1937	2,792,790	928,742	3,721,532	1,277,664	**16,507,268**	2,443,868
1938	2,243,571	810,493	3,054,064	1,213,186	**17,348,146**	1,840,878
1939	2,058,455	340,667	2,399,122	1,264,256	**18,483,012**	1,134,866
1940	1,607,012	286,338	1,893,350	1,351,847	**19,024,515**	541,503
1941	1,538,989	429,974	1,968,963	1,404,182	**19,589,296**	564,781
1942	1,618,925	260,051	1,878,976	1,385,479	**20,082,793**	493,497
1943	1,202,368	282,418	1,484,786	1,503,427	**20,064,152**	— 18,641
1944	1,556,192	511,308	2,067,500	1,678,421	**20,453,231**	389,079
1945	1,690,315	419,984	2,110,299	1,736,717	**20,826,813**	373,582
Crude Oil Only						
1944	.....	.....	.....	.....	**19,784,530**	.....
1945	.....	.....	.....	.....	**19,941,846**	.....
1946	2,413,628	244,434	2,658,062	1,726,348	**20,873,560**	931,714
1947	2,019,140	445,430	2,464,570	1,850,445	**21,487,685**	614,125
1948	3,398,726	396,481	3,795,207	2,002,448	**23,280,444**	1,792,759
1949	2,297,428	890,417	3,187,845	1,818,800	**24,649,489**	1,369,045
1950	1,997,769	564,916	2,562,685	1,943,776	**25,268,398**	618,909
1951	4,024,698	389,256	4,413,954	2,214,321	**27,468,031**	2,199,633
1952	2,252,860	496,428	2,749,288	2,256,765	**27,960,554**	492,523
1953	2,704,450	591,680	3,296,130	2,311,856	**28,944,828**	984,274
1954	2,287,231	585,806	2,873,037	2,257,119	**29,560,746**	615,918
1955	2,393,767	476,957	2,870,724	2,419,300	**30,012,170**	451,424
1956	2,507,114	467,222	2,974,336	2,551,857	**30,434,649**	422,479
[3] Natural Gas Liquids						
1946	.....	.....	.....	.....	**3,163,219**	.....
1947	192,237	59,301	251,538	160,782	**3,253,975**	90,756
1948	405,874	64,683	470,557	183,749	**3,540,783**	286,808
1949	294,211	92,565	386,776	198,547	**3,729,012**	188,229
1950	707,879	58,183	766,062	227,411	**4,267,663**	538,651
1951	648,497	75,494	723,991	267,052	**4,724,602**	456,939
1952	475,170	81,668	556,838	284,789	**4,996,651**	272,049
1953	648,047	95,922	743,969	302,698	**5,437,922**	441,271
1954	20,830	86,520	107,350	300,815	**5,244,457**	—193,465
1955	447,160	67,348	514,508	320,400	**5,438,565**	194,108
1956	715,764	94,056	809,820	346,053	**5,902,332**	463,767
[4] Total Liquid Hydrocarbons						
1946	.....	.....	.....	.....	**24,036,779**	.....
1947	2,211,377	504,731	2,716,108	2,011,227	**24,741,660**	704,881
1948	3,804,600	461,164	4,265,764	2,186,197	**26,821,227**	2,079,567
1949	2,591,639	982,982	3,574,621	2,017,347	**28,378,501**	1,557,274
1950	2,705,648	623,099	3,328,747	2,171,187	**29,536,061**	1,157,560
1951	4,673,195	464,750	5,137,945	2,481,373	**32,192,633**	2,656,572
1952	2,728,030	578,096	3,306,126	2,541,554	**32,957,205**	764,572
1953	3,352,497	687,602	4,040,099	2,614,554	**34,382,750**	1,425,545
1954	2,308,061	672,326	2,980,387	2,557,934	**34,805,203**	422,453
1955	2,840,927	544,305	3,385,232	2,739,700	**35,450,735**	645,532
1956	3,222,878	561,278	3,784,156	2,897,910	**36,336,981**	886,246

[1] See footnote to Table 2. [2] Includes cycle plant and lease condensate. [3] Condensate, natural gasoline, and liquefied petroleum gases. [4] Crude oil and natural gas liquids.

CHANGING PANORAMA . . .

tive year that annual additions to proved crude oil reserves declined. New discoveries compared favorably with earlier years, the API stated. But the constantly increasing output makes the net additions smaller.

In proving up 3 billion barrels of new crude reserves in 1956, the industry drilled more than 58,000 wells, a record number. While that large volume of crude was proved up, over 2.5 billion barrels were produced. The result was a net addition of only 422 million barrels to crude reserves, the total rising to 30.4 billion barrels. That was the smallest net addition since the war. In 4 out of the first 6 postwar

TABLE 2

Summary of Changes in 1956 in Proved U. S. Reserves of Liquid Hydrocarbons

Sources: Crude oil from API; natural gas liquids from API and AGA

(THOUSANDS OF BARRELS)

CRUDE OIL		
Total proved reserves, Dec. 31, 1955		30,012,170
Revisions of previous estimates	+804,803	
Extensions of old pools	1,702,311	
New reserves discovered in 1956 in new fields and in new pools in old fields	467,222	
Proved reserves added in 1956		2,974,336
Total proved reserves, Dec. 31, 1955 plus new proved reserves added in 1956		32,986,506
*Less production during 1956		2,551,857
Total proved reserves Dec. 31, 1956		30,434,649
Change in reserves during 1956		+422,479
NATURAL GAS LIQUIDS		
Total proved reserves Dec. 31, 1955		5,438,565
Revisions of previous estimates and extensions of old pools	+715,764	
New reserves discovered in 1956 in new fields and in new pools in old fields	94,056	
Proved reserves added in 1956		809,820
Total proved reserves Dec. 31, 1955 plus new proved reserves added in 1956		6,248,385
*Less production during 1956		346,053
Total proved reserves Dec. 31, 1956		5,902,332
Change in reserves during 1956		+463,767
TOTAL LIQUID HYDROCARBONS		
Total proved reserves Dec. 31, 1955		35,450,735
Revisions of previous estimates and extensions of old pools	+3,222,878	
New reserves discovered in 1956 in new fields and in new pools in old fields	561,278	
Proved reserves added in 1956		3,784,156
Total proved reserves Dec. 31, 1955 plus new proved reserves added in 1956		39,234,891
*Less production during 1956		2,897,910
Total proved reserves Dec. 31, 1956		36,336,981
Change in reserves during 1956		+886,246

* The 1956 production figures were compiled by the committee from records of actual production for whatever period such were available, with estimates for the remainder of the year. Any variance between the actual production, as later reported, and the figures used herein will be compensated for through revision when the following year's reserve report is compiled. These revisions have in the past been very small. Because, in each annual report by this committee, the production figure for the year is an estimate, as just explained, correct total cumulative production cannot be obtained by adding together the figures listed in successive reports of this committee, or in the columns marked "production" of tables 1 and 3.

TABLE 3—Estimated Proved Reserves of Liquid Hydrocarbons in U. S. and Canada, by Areas

Sources: For U. S., crude oil from API and natural gas liquids from API and AGA. For Canada, all data via API from Canadian Petroleum Association.

THOUSANDS OF BARRELS

STATE or PROVINCE	Proved Reserves Dec. 31, 1955	Added in 1956 by Extensions and Revisions	[1]Discovered in 1956 in New Fields and New Pools in Old Fields	[2] Production During 1956	Proved Reserves Dec. 31, 1956 (Columns 1 + 2 + 3 Less Column 4)	Changes in Reserves During 1956 (Column 5 Less Column 1)
	(1)	(2)	(3)	(4)	(5)	(6)
UNITED STATES Crude Oil						
Alabama	**20,604**	19,897	.....	2,964	**37,537**	16,933
Arkansas	**329,539**	12,089	3,947	27,849	**317,726**	—11,813
[3]California	**3,801,408**	301,800	18,903	350,754	**3,771,357**	—30,051
Colorado	**334,003**	82,965	5,202	58,420	**363,750**	29,747
Illinois	**691,161**	77,878	13,003	82,042	**700,000**	8,839
Indiana	**61,458**	17,589	956	12,275	**67,728**	6,270
Kansas	**998,068**	97,206	21,496	124,559	**992,211**	—5,857
Kentucky	**107,454**	55,068	3,448	17,528	**148,442**	40,988
[3]Louisiana	**3,255,287**	574,741	115,387	269,996	**3,675,419**	420,132
Michigan	**58,889**	7,094	75	10,746	**55,312**	—3,577
Mississippi	**387,702**	13,822	5,731	39,050	**368,205**	—19,497
Montana	**298,948**	46,387	7,800	21,721	**331,414**	32,466
Nebraska	**57,697**	14,294	7,720	16,850	**62,861**	5,164
New Mexico	**819,658**	81,745	21,150	87,116	**835,437**	15,779
New York	**42,943**	.....	.....	2,747	**40,196**	—2,747
North Dakota	**185,532**	11,947	11,110	12,755	**195,834**	10,302
Ohio	**56,000**	12,498	.....	4,923	**63,575**	7,575
Oklahoma	**2,016,045**	175,697	29,867	211,811	**2,009,798**	—6,247
Pennsylvania	**93,344**	49,587	.....	8,231	**134,700**	41,356
[3]Texas	**14,933,502**	762,934	164,488	1,077,785	**14,783,139**	—150,363
Utah	**37,112**	283	26,550	2,510	**61,435**	24,323
West Virginia	**47,000**	3,320	3,138	2,237	**51,221**	4,221
Wyoming	**1,373,630**	88,621	7,251	106,338	**1,363,164**	—10,466
[4]Miscellaneous	**5,186**	—348	.....	650	**4,188**	—998
Total U.S.	**30,012,170**	2,507,114	467,222	2,551,857	**30,434,649**	422,479
[5]Natural Gas Liquids						
[6]Alabama	.....	.....	.....	.....	.....	.....
Arkansas	**45,124**	338	18	3,013	**42,467**	—2,657
[3]California	**324,941**	16,548	663	30,424	**311,728**	—13,213
Colorado	**12,511**	—129	.....	837	**11,545**	—966
Illinois	**18,457**	464	92	2,241	**16,772**	—1,685
Indiana	**132**	17	5	21	**133**	1
Kansas	**173,236**	2,111	1,944	5,676	**171,615**	—1,621
Kentucky	**8,675**	291	145	1,860	**7,251**	—1,424
[3]Louisiana	**935,950**	98,628	23,589	43,225	**1,014,942**	78,992
Michigan	**872**	178	134	116	**1,068**	196
Mississippi	**57,876**	—215	1,421	3,079	**56,003**	—1,873
Montana	**6,857**	1,550	.....	262	**8,145**	1,288
Nebraska	**6,436**	436	183	551	**6,504**	68
New Mexico	**342,207**	84,574	2,489	15,171	**414,099**	71,892
Ohio	**1,557**	120	13	21	**1,669**	112
Oklahoma	**354,354**	26,131	5,963	30,860	**355,588**	1,234
Pennsylvania	**3,024**	178	89	124	**3,167**	143
[3]Texas	**3,045,361**	476,364	57,037	198,873	**3,379,889**	334,528
Utah	**108**	—8	.....	5	**95**	—13
West Virginia	**30,526**	761	253	4,799	**26,741**	—3,785
Wyoming	**50,348**	7,420	.....	3,894	**53,874**	3,526
[7]Miscellaneous	**20,013**	7	18	1,001	**19,037**	—976
Total U.S.	**5,438,565**	715,764	94,056	346,053	**5,902,332**	463,767
[8]Total Liquid Hydrocarbons						
[9]Alabama	**20,604**	19,897	.....	2,964	**37,537**	16,933
Arkansas	**374,663**	12,427	3,965	30,862	**360,193**	—14,470
[3]California	**4,126,349**	318,348	19,566	381,178	**4,083,085**	—43,264
Colorado	**346,514**	82,836	5,202	59,257	**375,295**	28,781
Illinois	**709,618**	78,342	13,095	84,283	**716,772**	7,154
Indiana	**61,590**	17,606	961	12,296	**67,861**	6,271
Kansas	**1,171,304**	99,317	23,440	130,235	**1,163,826**	—7,478
Kentucky	**116,129**	55,359	3,593	19,388	**155,693**	39,564
[3]Louisiana	**4,191,237**	673,369	138,976	313,221	**4,690,361**	499,124
Michigan	**59,761**	7,272	209	10,862	**56,380**	—3,381
Mississippi	**445,578**	13,607	7,152	42,129	**424,208**	—21,370
Montana	**305,805**	47,937	7,800	21,983	**339,559**	33,754
Nebraska	**64,133**	14,730	7,903	17,401	**69,365**	5,232
New Mexico	**1,161,865**	166,319	23,639	102,287	**1,249,536**	87,671
[9]New York	**42,943**	.....	.....	2,747	**40,196**	—2,747
[9]North Dakota	**185,532**	11,947	11,110	12,755	**195,834**	10,302
Ohio	**57,557**	12,618	13	4,944	**65,244**	7,687
Oklahoma	**2,370,399**	201,828	35,830	242,671	**2,365,386**	—5,013
Pennsylvania	**96,368**	49,765	89	8,355	**137,867**	41,499
[3]Texas	**17,978,863**	1,239,298	221,525	1,276,658	**18,163,028**	184,165
Utah	**37,220**	275	26,550	2,515	**61,530**	24,310
West Virginia	**77,526**	4,081	3,391	7,036	**77,962**	436
Wyoming	**1,423,978**	96,041	7,251	110,232	**1,417,038**	—6,940
[10]Miscellaneous	**25,199**	—341	18	1,651	**23,225**	—1,974
Total U.S.	**35,450,735**	3,222,878	561,278	2,897,910	**36,336,981**	886,246
CANADA Crude Oil						
Northwest Territories	**53,707**	.....	.....	449	**53,258**	—449
Alta. and Br. Col.	**2,169,985**	344,213	19,721	142,141	**2,391,778**	221,793
Saskatchewan	**236,872**	113,711	28,394	20,284	**358,693**	121,821
Manitoba	**45,211**	2,577	56	5,839	**42,005**	—3,206
Ont.-N. Brunswick	**3,759**	465	20	608	**3,636**	—123
Total Crude Oil	**2,509,534**	460,966	48,191	169,321	**2,849,370**	339,836
[11]Natural Gas Liquids	**247,085**	20,505	15,000	2,656	**279,934**	32,849
Total Liquid Hydrocarbons	**2,756,619**	481,471	63,191	171,977	**3,129,304**	372,685

[1] Limited area assigned to a discovery until proved larger. [2] See footnote to Table 2. [3] Includes off-shore reserves. [4] Ariz., Fla., Mo., Nev., S.D., Tenn., Va. [5] Condensate, natural gasoline, LPG. [6] Incl. in Miscl. [7] Ala., Fla., N.D. [8] Crude oil and natural gas liquids. [9] Crude oil only. [10] Ala. and N.D. natural gas liquids; Ariz., Mo., Nev., S.D., Tenn., and Va. crudes; and Fla. crude and natural gas liquids. [11] All in Alta. and Br. Columbia.

years, net increases in proved crude reserves ranged from 1 billion to 2 billion barrels.

The 3 billion barrels of new crude proved in 1956 was almost exactly the average for the 11 years since the war, although more and deeper wells were drilled than postwar annual averages.

Natural Gas Liquids. U. S. reserves of natural gas liquids at end of 1956 were estimated at 5.9 billion barrels, up 464 million barrels from a year earlier. That was the largest annual increase since the war with exception of the 539 million barrel gain of 1950, when production was much lower. New reserves proved up in 1956 totaled 810 million barrels, a postwar record, while production amounted to 346 million barrels.

Canada. The 3.1 billion barrels of Canadian reserves of liquid hydrocarbons at end of 1956 included 2,849,370,000 barrels of crude and 279,934,000 barrels of natural gas liquids. During the year, operators proved up 509 million barrels of crude, while 169 million were produced, making a net increase of 340 million barrels in crude reserves. In 1956, 35.5 million barrels of natural gas liquids were developed, while 2.7 million barrels were produced, providing a net gain of 32.8 million barrels in reserves.

TABLE 4

Summary of Changes in 1956 in Proved U. S. Reserves of Natural Gas

(Source: American Gas Association)

Millions of Cubic Feet—14.65 psia, at 60° F.

Total proved reserves Dec. 31, 1955		223,697,445
Extensions and revisions of previous estimate during 1956	19,214,604	
New reserves discovered in 1956	5,636,476	
Net changes in underground storage during 1956	133,970	
Total proved reserves added and net changes in underground storage during 1956		24,985,050
Total proved reserves Dec. 31, 1955 and additions during 1956		248,682,495
Deduct production during 1956		10,907,926
Total proved reserves Dec. 31, 1956		237,774,569
Increase in reserves during 1956		14,077,124

TABLE 5—Estimated Proved Reserves of Natural Gas in U. S., by Years

Source: AGA . . . Millions of Cubic Feet—14.65 psia, at 60 Deg. F.

Year	NATURAL GAS ADDED DURING YEAR: Extensions and Revisions	Discoveries of New Fields and New Pools in Old Fields	Total of Discoveries Revisions and Extensions	Net Change in Storage	Net Production During Year	Estimated Proved Reserves as of End of Year	Increase Over Previous Year
1945	.....	.....	.....	.....	.....	**147,789,367**	.....
1946	*	*	17,729,152	*	4,942,617	**160,575,901**	12,786,534
1947	7,570,654	3,410,170	10,980,824	*	5,629,811	**165,926,914**	5,351,013
1948	9,769,483	4,129,089	13,898,572	51,482	6,007,628	**173,869,340**	7,942,426
1949	8,061,429	4,612,870	12,674,299	82,746	6,245,041	**180,381,344**	6,512,004
1950	9,172,381	2,877,351	12,049,732	54,301	6,892,678	**185,592,699**	5,211,355
1951	13,013,606	3,039,385	16,052,991	132,751	7,966,941	**193,811,500**	8,218,801
1952	8,934,470	5,411,043	14,345,513	198,850	8,639,638	**199,716,225**	5,904,725
1953	13,371,355	7,081,661	20,453,016	516,431†	9,238,540	**211,447,132**	11,730,907
1954	4,632,309	4,966,894	9,599,203	90,906	9,426,509	**211,710,732**	263,600
1955	16,298,125	5,719,069	22,017,194	87,637	10,118,118	**223,697,445**	11,986,713
1956	19,214,604	5,636,476	24,851,080	133,970	10,907,926	**237,774,569**	14,077,124

* Not estimated. † All native gas in storage reservoirs formerly classified as a natural gas reserve is included in this figure.

TABLE 6—Estimated Proved Recoverable Reserves of Natural Gas in U. S., by States

Source: American Gas Association

(Millions of Cubic Feet—14.65 psia, at 60 deg. F)

STATE	[2]Reserves As of December 31, 1955	CHANGES IN RESERVES DURING 1956: [2]Extensions and Revisions	[2]Discoveries of New Fields and New Pools in Old Fields	[3]Net Change in Underground Storage	[4]Net Production	[2]RESERVES AS OF DECEMBER 31, 1956: Total (Columns 7+8+9+10 Also Columns 1+2+3+4 Less Column 5)	[5]Non-Associated	[6]Associated	[7]Dissolved	[8]Underground Storage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Arkansas	**1,164,367**	2,990	38,457	—551	33,736	**1,171,527**	554,908	323,260	288,762	4,597
[9]California	**8,892,950**	258,495	76,317	11,264	487,793	**8,751,233**	2,164,272	2,058,459	4,462,694	65,808
Colorado	**2,253,562**	187,523	73,161	3,291	94,768	**2,422,769**	1,611,749	131,977	675,752	3,291
Illinois	**233,565**	2,574	1,395	7,180	25,009	**219,705**	5,535	500	186,026	27,644
Indiana	**33,111**	4,289	0	477	4,105	**33,772**	2,050	1,880	22,621	7,221
Kansas	**16,293,080**	1,652,569	195,316	3,042	577,750	**17,566,257**	17,022,526	146,698	340,400	56,633
Kentucky	**1,262,270**	46,051	7,600	1,681	72,000	**1,245,602**	1,161,206	0	62,617	21,779
[9]Louisiana	**42,435,592**	2,910,172	1,630,589	0	1,922,354	**45,053,999**	35,490,462	6,548,729	3,014,808	0
Michigan	**325,874**	4,562	15,377	27,995	12,022	**361,786**	45,596	20,680	61,418	234,092
Mississippi	**2,608,340**	—29,648	43,592	1,273	220,231	**2,403,326**	1,627,795	500,852	272,464	2,215
Montana	**719,719**	6,094	718	438	30,618	**696,351**	549,031	36,203	80,336	30,781
Nebraska	**203,421**	39,174	8,182	0	25,375	**225,402**	121,487	12,608	91,307	0
New Mexico	**18,584,912**	5,222,559	340,232	—33,116	641,880	**23,472,707**	17,052,725	4,694,721	1,673,733	51,528
New York	**75,760**	5,127	1,420	6,877	3,935	**85,249**	37,024	0	287	47,938
North Dakota	**280,696**	112,270	20,512	0	15,985	**397,493**	6,307	0	391,186	0
Ohio	**809,874**	39,845	6,390	29,225	31,727	**853,607**	532,226	0	37,960	283,421
Oklahoma	**13,204,739**	1,249,397	234,480	3,035	916,602	**13,775,049**	6,483,823	3,432,600	3,768,640	89,986
Pennsylvania	**754,389**	97,573	9,915	32,751	118,416	**776,212**	419,111	0	31,165	325,936
[9]Texas	**108,287,548**	6,944,630	2,829,100	2,423	5,334,951	**112,728,750**	70,801,507	25,580,088	16,329,920	17,235
Utah	**420,896**	170,461	46,949	0	18,520	**619,786**	546,361	19,075	54,350	0
Virginia	**34,756**	2,813	937	0	2,949	**35,557**	35,557	0	0	0
West Virginia	**1,564,899**	121,564	25,250	32,995	182,971	**1,561,737**	1,288,602	0	64,033	209,102
Wyoming	**3,196,103**	152,232	16,932	—199	129,136	**3,235,932**	2,416,326	186,729	614,658	18,219
[1]Miscellaneous	**57,022**	11,288	13,655	3,889	5,093	**80,761**	56,727	0	19,225	4,809
Total	**223,697,445**	19,214,604	5,636,476	133,970	10,907,926	**237,774,569**	160,032,913	43,695,059	32,544,362	1,502,235

[1] Includes Alabama, Arizona, Florida, Iowa, Maryland, Missouri and Nevada. [2] Excludes gas loss due to natural gas liquids recovery. [3] The net difference between gas stored in and gas withdrawn from underground storage reservoirs, inclusive of adjustments and native gas transferred from other reserve categories. [4] Net production equals gross withdrawals less gas injected into producing reservoirs. Changes in underground storage and gas loss due to natural gas liquids recovery are excluded. Fourth quarter production estimated in some instances. [5] Non-Associated Gas is free gas not in contact with crude oil in the reservoir; and free gas in contact with oil where the production of such gas is not significantly affected by the production of crude oil. [6] Associated Gas is free gas in contact with crude oil in the reservoir where the production of such gas is significantly affected by the production of crude oil. [7] Dissolved gas is gas in solution with crude oil in the reservoirs. [8] Gas held in underground reservoirs (including native and net injected gas) for storage purposes. [9] Includes off-shore reserves.

By **RAY L. DUDLEY,** Publisher, and **WARREN L. BAKER,** Editor

Demand Variations Complicate Outlook

Crude markets enhanced by reduced April allowable, but lower demand in coming months makes curtailment of imports and refining output extremely vital.

Oil's outlook is improved by reduced April crude producing allowables. Now it remains for refining output and oil imports to undergo similar reductions. The latter two actions would prove tremendously helpful in improving the industry's whole supply-demand picture.

The need for reduced operating levels is brought about by lower demand for U. S. oils. Demand will be much smaller in April than in recent months. This is a normal seasonal trend because of reduced heating oil use.

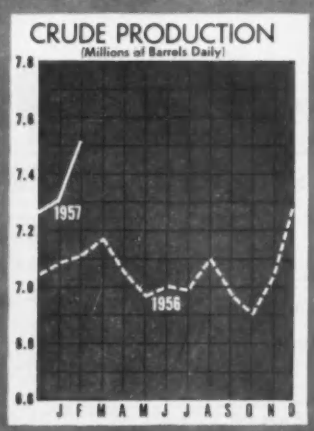
Because of the uncertainty surrounding Western Europe's need for U. S. oil during the next few months, it is particularly important that U. S. producing, refining and import levels be held to reasonable limits during 1957. The situation calls for maximum caution because of the possibility of sudden downward fluctuations far sharper than in normal years.

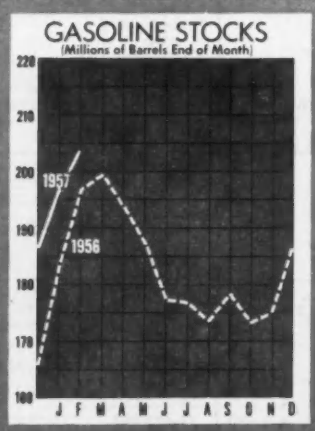
Now that the producing branch has led the way, it is up to refiners and imports to cooperate by taking similar steps. If all segments of the industry operate at levels which will prevent excessive supply, the industry will not find it necessary to cure surplus inventories in future months.

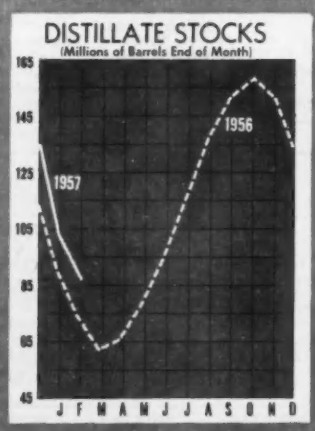
Lower producing allowables for April promise that domestic crude oil supplies will be in line with requirements during the month. The U. S. Bureau of Mines has forecast that April demand for U. S. crude will be 600,000 barrels per day less than in March. This reflects normal reduction in U. S. requirements and reduced European needs. The latter is the result of lessened needs plus possibility Europe may receive increased Middle East oil due to partial restoration of Iraq pipe lines.

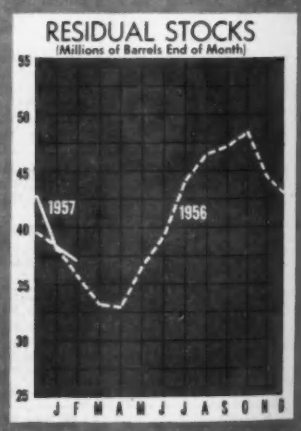
Consequently, market prospects are greatly enhanced by reduced allowables in Texas, New Mexico and Lou-

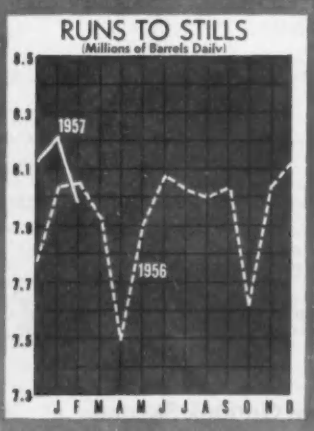
Petroleum Trends . . .

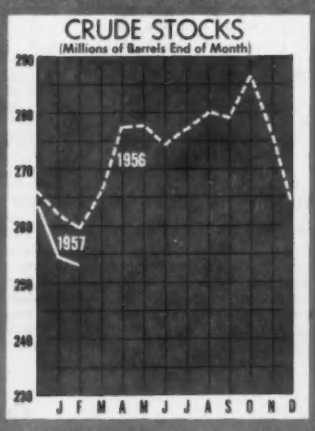


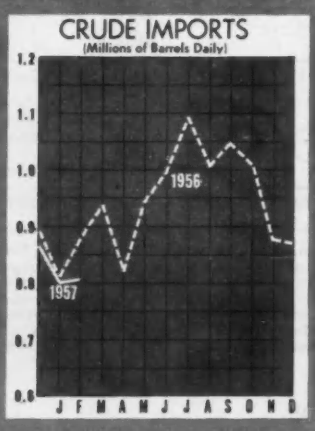


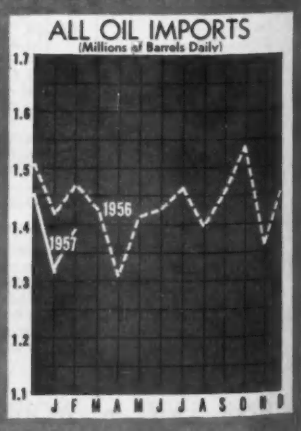












isiana. Texas' April allowable will be nearly 225,000 barrels per day less than in March. Louisiana trimmed its April allowable by 60,000 to 70,000 barrels daily, and New Mexico's output will be down 2000 barrels per day.

U. S. crude stocks during the past month remained unchanged. On March 9 they totaled 252 million barrales. In view of reduced demand in April, continuation of March record producing rates would have meant very large additions to inventories of crude oil in April. Stocks are still likely to show some growth in April, but the increase will be at a more reasonable rate than otherwise would be true.

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Refining runs need to be cut below recent levels because of the seasonal decline in oil demand. During the first two weeks in March, crude runs to U. S. refineries have averaged just over 8 million barrels daily. This is practically the same as in February, and compares with 8,205,000 barrels per day in January.

Reduced refinery runs have greatly improved the supply-demand relationship of gasoline. Also of great help has been adjusted yields, which have curtailed gasoline output while boosting distillate fuel production.

As a result gasoline stocks rose slowly during the past four weeks. On March 15 inventories of motor fuel totaled 205½ million barrels, only 3 million barrels larger than a month ago. At current levels gasoline stocks are 9½ million barrels above year ago levels. However, at the beginning they had been 13¼ million barrels above the corresponding period of 1956.

Gasoline stocks will commence declining in April, as the motor fuel consuming season is entered.

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Oil imports also should be reduced during coming months. Unfortunately, no signs of a reduction have been forthcoming so far. During the week ended March 15, latest figures available, imports rose to a new all-time high of nearly 1,700,000 barrels per day.

Now that Middle East shipments likely will be increasing, there is a definite possibility that imports will rise even higher. This would be most undesirable. Imports should be curtailed, along with U. S. production, to fit the nation's oil needs.

U. S. Crude Production

(THOUSANDS OF BARRELS)

STATE or DISTRICT	DAILY AVERAGE PRODUCTION				TOTAL PRODUCTION FIRST TWO MONTHS		
	Feb., 1957	Jan., 1957	Feb., 1956	% Diff. Feb., 1957-1956	1957	1956	% Diff. 1957-1956
Alabama	11.4	11.5	4.9	+132.7	676	293	+130.7
Arkansas	81.0	80.2	76.9	+ 5.3	4,758	4,585	+ 3.8
California	937.1	943.5	969.8	— 3.4	55,488	58,239	— 4.7
Colorado	158.7	159.7	161.8	— 1.9	9,394	9,578	— 1.9
Florida	1.2	1.2	1.3	— 7.7	74	82	— 9.8
Illinois	232.9	234.4	222.7	+ 4.6	13,788	13,424	+ 2.7
Indiana	32.2	32.6	28.1	+ 14.6	1,910	1,665	+ 14.7
Kansas	351.8	336.6	338.0	+ 4.1	20,289	20,300	— 0.1
Kentucky	50.0	48.2	48.6	+ 2.3	2,895	2,871	+ 0.8
Louisiana	978.0	978.1	805.0	+ 21.5	57,703	47,989	+ 20.2
North Louisiana	130.0	131.4	127.8	+ 1.7	7,710	7,568	+ 1.9
South Louisiana	848.0	846.7	677.2	+ 25.2	49,993	40,421	+ 23.7
Michigan	27.2	26.6	34.1	— 20.2	1,584	1,922	— 17.6
Mississippi	112.8	113.8	110.7	+ 1.9	6,687	6,653	+ 0.5
Missouri	0.2	0.2	0.2	.....	9	10	— 10.0
Montana	72.2	69.2	54.0	+ 33.7	4,169	3,263	+ 27.8
Nebraska	38.4	38.5	40.2	— 4.5	2,270	2,291	— 0.9
Nevada	0.1	0.1	0.2	— 50.0	6	13	— 53.9
New Mexico	257.9	249.0	234.7	+ 9.9	14,939	14,479	+ 3.2
Southeast New Mexico	254.9	246.0	232.5	+ 9.6	14,778	14,324	+ 3.2
Northwest New Mexico	3.0	2.6	2.2	+ 36.4	161	155	+ 3.9
New York	6.5	7.0	7.7	— 15.6	397	453	— 12.4
North Dakota	36.2	38.8	35.7	+ 1.4	2,217	2,409	— 8.0
Ohio	13.4	12.2	12.6	+ 6.3	752	747	+ 0.7
Oklahoma	641.6	613.2	617.9	+ 3.8	36,977	36,826	+ 0.4
Pennsylvania	24.2	21.7	21.2	+ 14.2	1,353	1,330	+ 1.7
South Dakota	0.1	0.1	0.1	.....	3	3	.....
Tennessee	0.1	0.1	0.1	.....	3	3	.....
Texas	3,131.0	3,078.1	3,081.7	+ 1.6	183,090	184,770	— 0.9
Dist. 1: South Central	56.5	56.0	53.2	+ 6.2	3,318	3,057	+ 8.5
Dist. 2: Middle Gulf	161.0	154.3	159.8	+ 0.8	9,290	9,639	— 3.6
Dist. 3: Upper Gulf	459.6	459.6	465.8	— 1.3	27,117	27,610	— 1.8
Dist. 4: Lower Gulf	244.6	236.8	251.3	— 2.3	14,190	14,968	— 5.2
Dist. 5: East Central	42.4	39.8	47.0	— 9.8	2,422	2,806	— 13.7
Dist. 6: Northeast	358.7	343.2	359.1	— 0.1	20,683	21,471	— 3.7
Dist. 7-B: North Central	165.1	161.9	156.0	+ 5.8	9,642	9,187	+ 5.0
Dist. 7-C: West Central	174.6	171.6	182.8	— 4.5	10,212	10,697	— 4.5
Dist. 8: West	1,157.4	1,143.9	1,049.4	+ 10.3	67,866	61,862	+ 9.7
Dist. 9: North	212.8	209.4	208.7	+ 2.0	12,447	12,163	+ 2.3
Dist. 10: Panhandle	98.3	101.6	93.2	+ 5.5	5,902	5,559	+ 6.2
Utah	11.8	10.5	5.9	+100.0	655	358	+ 83.0
Virginia	0.1	0.1	0.1	.....	2	2	.....
West Virginia	6.1	5.8	6.2	— 1.6	352	358	— 1.7
Wyoming	301.4	300.7	287.6	+ 4.8	17,761	17,271	+ 2.8
Total United States	7,515.6	7,411.7	7,208.0	+ 4.3	440,201	432,187	+ 1.9

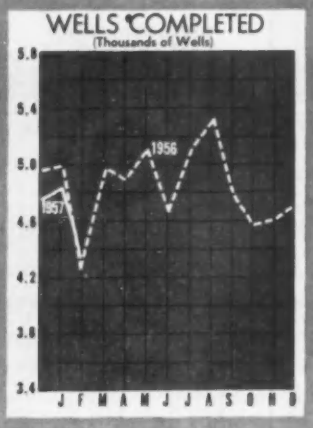
U. S. Crude Oil and Refined Product Trends

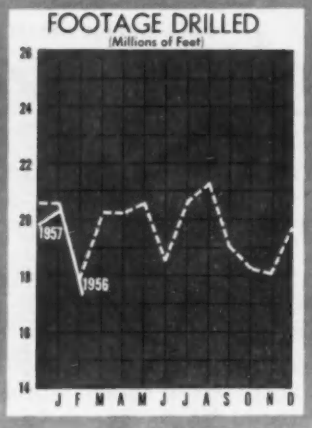
(THOUSANDS OF BARRELS)

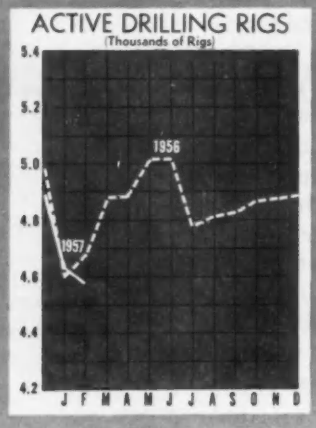
MONTH	CRUDE OIL			GASOLINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1955:											
July	6,632	7,580	264,601	3,824	157,079	1,575	119,169	1,091	44,894	860	1,161
August	6,665	7,580	256,427	3,858	151,912	1,621	133,675	1,090	45,480	756	1,155
September	6,731	7,483	256,269	3,784	150,194	1,621	143,248	1,061	46,267	829	1,218
October	6,831	7,465	267,346	3,827	153,103	1,612	152,288	1,123	47,040	821	1,206
November	7,014	7,692	260,707	3,867	157,871	1,680	141,808	1,214	44,071	823	1,322
December	7,155	7,762	265,610	3,916	165,433	1,765	111,333	1,286	39,174	884	1,502
1956:											
January	7,199	8,023	261,592	3,927	183,905	1,923	86,141	1,344	38,247	805	1,422
February	7,208	8,047	259,504	3,854	196,092	1,918	71,335	1,286	35,673	878	1,472
March	7,278	7,914	265,683	3,829	199,698	1,808	60,846	1,213	32,984	934	1,425
April	7,146	7,487	277,121	3,646	193,299	1,713	63,571	1,130	32,740	815	1,305
May	7,064	7,896	277,497	3,859	186,673	1,667	75,928	1,149	36,607	938	1,416
June	7,100	8,071	274,491	3,976	177,076	1,755	93,758	1,098	39,073	987	1,426
July	7,090	8,014	277,008	3,975	176,536	1,767	115,787	1,066	43,958	1,084	1,463
August	7,195	7,995	279,944	4,037	172,939	1,839	137,905	1,091	46,617	1,001	1,399
September	7,054	8,024	278,791	3,991	177,974	1,845	150,411	1,062	47,342	1,043	1,452
October	6,966	7,608	286,560	3,773	172,798	1,772	158,871	1,082	48,400	1,004	1,541
November	7,139	8,031	275,995	3,913	174,808	1,841	151,517	1,182	44,590	871	1,362
December	7,377	8,141	266,014	4,039	187,271	1,981	133,981	1,288	44,491	873	1,471
1957:											
January	7,412	8,205	254,048	3,900	196,351	2,077	100,369	1,270	38,212	796	1,317
February	7,516	7,992	253,093	3,789	203,749	2,029	85,698	1,243	37,068	802	1,389
Week Ended:											
3-15-57	7,799	8,098	*251,993	3,726	205,589	1,949	79,599	1,218	36,283	908	1,697
3-16-56	7,153	7,986	255,993	3,722	195,941	1,844	67,386	1,292	35,038	1,008	1,399

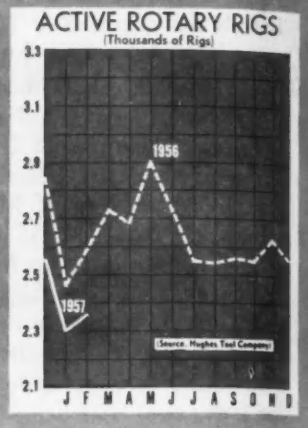
* March 8.

Drilling Activities . . .









February's Wells Drop, But Year Not Far Off '56 Pace

By CECIL W. SMITH, WORLD OIL Staff

AS EXPECTED, the number of new wells completed in the U. S. during February was considerably less than those recorded in January. But taking into account the short month, the daily completion rate was only slightly under that of the previous period. The probability that it will be at least another month before activity turns upward was strongly indicated by the fact that there were slightly fewer drilling rigs in the field at the close of February than were at work a month previously.

This easing of drilling activity is generally believed by industry observers to be temporary and that it will soon be back to last year's rate. However, at the end of two months' experience, new wells drilled trailed last year's by 1.5 percent and footage was lagging by 1.8 percent.

February's record showed a total of 4306 new wells completed in the nation, against January's 4808. However, on a daily average basis, the latter month's tests amounted to almost 154 a day, while January's averaged 155 daily. A year earlier, new wells were completed at the rate of only 144 a day during February.

The year's first two months saw a total of 9114 drilled, compared with 9255 in the same period of 1956. That was a decline of 1.5 percent. However, making allowance for last year's extra day in February, there was only a minute difference in the two period's activity.

Footage drilled in two months totaled 37,810,000 feet, which was 1.8 percent less than the 38,486,000 feet recorded in last year's comparable period. By reason of last year's additional day, that margin of difference was actually not that large. The principal difference was that each well was drilled to 4149 feet on the average, while the average in 1956 had been 4158 feet.

Summary of U. S. Drilling Activity

ITEM	Feb., 1957	Jan., 1957	TWO MONTHS January-February 1957	1956	Percent Diff.
New Wells Completed:					
Oil	2,365	2,624	4,989	4,905	+ 1.7
Distillate	40	53	93	108	—13.9
Gas	284	299	583	634	— 8.1
Service	81	81	162	134	+20.9
Dry	1,536	1,751	3,287	3,474	— 5.4
Total Wells	4,306	4,808	9,114	9,255	— 1.5
Footage Drilled (Mln. of Feet)	17.4	20.4	37.8	38.5	— 1.8

Drilling rigs active at the end of February numbered 4582, which was a small decline from the 4625 working a month earlier. It was also fewer than the 4677 being used a year before. The end-of-February rig count was the lowest it had been since February, 1955.

There has been an encouraging note in this year's drilling campaign and that was because a greater number of wells drilled proved to be producers than was true last year. The increase has been slight, but in the face of fewer wells drilled the fact is particularly heartening. Oil wells showed the way in this hike, while gas and gas-distillate producers failed to keep the pace.

The increase in producing wells was made even more encouraging by the fact that the number of wildcat tests has increased this year. Because wildcat odds are so low, a greater proportion of these tests usually throws the producer-to-failure ratio the other direction.

Summary of U. S. Wildcat Drilling

ITEM	Feb., 1957	Jan., 1957	TWO MONTHS January-February 1957	1956	Percent Diff.
New Field Discoveries:					
Oil	63	98	161	156	+ 3.2
Distillate	9	15	24	15	+60.0
Gas	22	19	41	34	+20.6
Total Discoveries	94	132	226	205	+10.2
Dry Wildcats	767	940	1,707	1,694	+ 0.8
Total Wildcats	861	1,072	1,933	1,899	+ 1.8
Percent Productive	10.9	12.3	11.7	10.8	.....
Percent Dry	89.1	87.7	88.3	89.2	.....

U. S. Drilling Activity in February and First Two Months, 1957-1956

STATE or DISTRICT	TOTAL NEW WELLS COMPLETED AND FOOTAGE DRILLED: DETAILS FOR FEBRUARY, 1957 Oil	Dist.	Gas	Dry	Service Wells	TOTAL NEW WELLS Feb., 1957	Jan., 1957	Feb., 1956	Total Footage February, 1957	DETAILS FOR JANUARY-FEBRUARY NEW WELLS 1957	1956	Percent Diff.	FOOTAGE 1957	1956	WILDCAT DRILLING IN FEBRUARY AND FIRST TWO MONTHS, 1957-1956: DETAILS FOR FEBRUARY, 1957 Oil	Dist.	Gas	Dry	Total Wildcats	DETAILS FOR JANUARY-FEBRUARY Oil	Dist.	Gas	Dry	TOTAL WILDCATS 1957	1956	DRILLING RIGS IN OPERATION Feb. 28, 1957	Jan. 31 1957	Feb. 29, 1956
Alabama	8	....	....	7	....	15	2	5	109,852	17	12	+ 41.7	132,923	97,352	....	....	....	7	7	....	....	....	7	7	3	24	20	10
Arizona	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1	....
Arkansas	46	....	2	19	....	67	115	48	184,270	182	117	+ 55.6	500,189	372,883	....	....	....	6	6	1	....	....	17	18	25	67	66	57
California	102	....	3	38	....	143	209	169	637,294	352	371	— 5.1	1,605,994	1,778,129	2	....	....	21	23	3	....	1	59	63	37	179	177	211
Colorado	15	....	9	50	....	74	86	101	409,396	160	234	— 31.6	835,277	1,247,850	....	....	1	41	42	2	....	2	92	96	104	46	57	59
Florida	....	....	....	1	....	1	1	4	4,021	2	5	— 60.0	16,240	28,170	....	....	....	1	1	....	....	....	2	2	5	1	2	....
Georgia	....	....	....	1	....	1	....	....	7,425	1	.....	+100.0	7,425	.....	....	....	....	1	1	....	....	....	1	1	.....	....	1	2
Idaho	....	....	....	....	....	....	1	....	....	1	.....	+100.0	3,947	.....	....	....	....	....	....	....	....	....	1	1	.....	1	1	....
Illinois	67	....	2	94	....	163	216	191	376,553	379	508	— 25.4	882,569	1,211,133	3	....	1	39	43	5	....	1	95	101	112	254	277	187
Indiana	21	....	6	59	....	86	31	29	143,513	117	93	+ 25.8	187,871	158,273	1	....	....	21	22	1	....	....	31	32	22	102	110	69
Kansas	183	....	24	143	15	365	358	354	1,239,006	723	704	+ 2.7	2,564,753	2,562,166	7	....	3	55	65	22	....	7	119	148	165	480	510	435
Kentucky	30	....	17	40	....	87	117	112	147,408	204	282	— 27.7	335,788	394,743	....	....	....	2	2	3	....	....	5	8	21	103	93	132
Louisiana	130	16	27	96	....	269	291	279	2,154,144	560	524	+ 6.9	4,820,702	4,250,280	3	6	3	33	45	6	10	3	77	96	79	423	412	396
North Louisiana	49	....	11	37	....	97	140	91	365,478	237	162	+ 46.3	849,281	623,660	....	....	....	12	12	1	1	....	26	28	20	77	67	72
South Louisiana	81	16	16	59	....	172	151	188	1,788,666	323	362	— 10.8	3,971,421	3,626,620	3	6	3	21	33	5	9	3	51	68	59	346	345	324
* Gulf of Mexico	57	8	7	21	....	93	35	39	878,057	93	71	+ 31.0	878,057	628,210	2	4	....	5	11	3	4	....	8	15	7	94	87	67
Maryland	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2
Michigan	16	....	....	12	....	28	35	37	87,176	63	91	— 30.8	199,257	259,634	2	....	....	9	11	3	....	....	24	27	29	62	57	71
Mississippi	12	....	1	17	....	30	27	34	210,413	57	73	— 21.9	408,893	535,446	1	....	....	13	14	4	....	....	24	28	30	28	29	36
Missouri	....	....	....	....	....	....	....	....	....	....	1	....	....	1,960	....	....	....	....	....	....	....	....	1	1	1	....	1	2
Montana	6	....	....	6	....	12	37	25	89,760	49	76	— 35.5	281,038	370,275	1	....	....	4	5	1	....	....	14	15	27	38	31	38
Nebraska	19	....	....	30	....	49	85	86	291,281	134	161	— 16.8	798,415	885,438	1	....	....	21	22	6	....	....	64	70	77	37	29	40
Nevada	....	....	....	....	....	....	1	....	....	1	1	....	3,386	7,885	....	....	....	....	....	....	....	....	1	1	.....	3	3	3
New Mexico	102	1	48	44	....	195	221	145	886,293	416	297	+ 40.1	1,863,190	1,441,623	6	....	1	23	30	9	....	2	50	61	32	155	152	154
New York	28	....	3	3	8	42	33	26	70,200	75	49	+ 53.1	128,500	71,900	....	....	....	....	....	....	....	....	....	....	.....	50	57	40
North Dakota	13	....	....	12	....	25	26	27	159,519	51	48	+ 6.3	339,005	370,329	....	....	....	11	11	2	....	....	20	22	14	22	22	21
Ohio	45	....	17	16	....	78	75	81	178,431	153	179	— 14.5	364,651	431,108	....	....	....	1	1	....	....	....	3	3	.....	228	218	212
Oklahoma	324	2	19	165	12	522	609	541	1,781,603	1,131	1,372	— 17.6	3,878,479	5,007,143	4	....	3	51	58	14	2	5	102	123	141	577	558	640
Oregon	....	....	....	....	....	....	....	1	....	....	1	....	....	12,880	....	....	....	....	....	....	....	....	....	....	1	....	....	....
Pennsylvania	23	....	16	7	23	69	74	57	205,739	143	120	+ 19.2	394,881	349,261	....	....	4	1	5	....	....	6	3	9	.....	156	162	134
South Dakota	....	....	....	4	....	4	2	1	14,517	6	1	+500.0	25,314	9,361	....	....	....	4	4	....	....	....	6	6	1	6	5	1
Texas	1,135	21	61	634	23	1,874	2,041	1,719	7,670,462	3,915	3,608	+ 8.5	16,376,484	15,279,486	30	3	4	385	422	74	12	9	849	944	887	1,261	1,288	1,467
Dist. 1: South Central	60	1	....	39	1	101	138	146	245,367	239	319	— 25.1	632,749	854,607	....	....	....	27	27	4	....	....	67	71	102	48	50	48
Dist. 2: Middle Gulf	16	6	10	24	....	56	67	58	363,057	123	147	— 16.3	785,539	919,103	....	1	2	13	16	....	2	4	36	42	35	39	40	50
Dist. 3: Upper Gulf	62	9	8	55	....	134	179	134	917,552	313	272	+ 15.1	2,167,796	1,806,275	1	1	....	33	35	6	4	1	81	92	79	133	140	151
* Gulf of Mexico	....	....	....	....	....	....	1	3	.....	4	3	+ 33.3	31,433	32,075	1	....	....	2	3	....	....	....	....	....	.....	1	1	4
Dist. 4: Lower Gulf-S.W.	45	4	3	45	....	97	126	125	524,267	223	232	— 3.9	1,165,212	1,275,143	4	....	....	26	30	6	2	....	67	75	81	68	77	82
* Gulf of Mexico	1	....	....	1	....	2	1	....	18,861	3	3	.....	27,571	31,176	....	....	....	....	....	....	....	....	....	....	.....	4	4	2
Dist. 5: East Central	3	....	1	9	....	13	16	9	64,499	29	42	— 31.0	161,346	140,534	....	....	....	8	8	1	1	....	19	21	23	7	10	16
Dist. 6: Northeast	43	....	13	29	....	85	104	64	489,328	189	150	+ 26.0	1,044,816	781,655	1	....	....	22	23	1	....	....	42	43	44	72	71	67
Dist. 7-B: North Central	84	....	3	113	....	200	261	211	627,183	461	567	— 18.1	1,535,504	1,876,292	8	....	1	84	93	19	....	1	140	160	197	117	120	155
Dist. 7-C: West Central	92	....	5	39	....	136	122	106	651,088	258	196	+ 31.6	1,184,657	947,525	5	....	....	27	32	9	....	1	65	75	47	90	99	135
Dist. 8: West	419	....	3	62	3	487	387	321	2,248,264	874	613	+ 42.6	4,303,114	3,125,509	6	....	....	36	42	13	....	1	82	96	91	326	319	413
Dist. 9: North	234	....	3	209	19	465	507	462	1,135,015	972	861	+ 12.9	2,465,487	2,774,833	4	....	....	104	108	12	....	....	236	248	168	238	251	255
Dist. 10: Panhandle	77	1	12	10	....	100	134	83	404,842	234	209	+ 12.0	929,864	778,010	1	1	1	5	8	3	3	1	14	21	20	123	111	95
Utah	3	....	....	4	....	7	9	7	41,369	16	29	— 44.8	93,838	146,689	....	....	....	3	3	1	....	....	5	6	23	36	38	19
Washington	....	....	....	....	....	....	....	1	.....	.....	1	.....	.....	7,493	....	....	....	....	....	....	....	....	....	.....	1	.....	.....	.....
West Virginia	4	....	28	5	....	37	53	49	111,797	90	127	— 29.1	261,641	334,264	....	....	2	....	2	....	....	4	2	6	.....	177	182	175
Wyoming	33	....	1	29	....	63	53	60	220,389	116	170	— 31.8	500,313	862,762	2	....	....	14	16	4	....	1	33	38	62	65	66	64
Total United States	2,365	40	284	1,536	81	4,306	4,808	4,190	17,431,831	9,114	9,255	— 1.5	37,810,563	38,485,916	63	9	22	767	861	161	24	41	1,707	1,933	1,899	4,582	4,625	4,677
Total Western Canada	172	....	12	65	....	249	224	196	1,144,566	473	455	+ 4.0	2,157,247	2,137,982	....	....	....	....	....	....	....	....	.....	.....	.....	232	196	233

*Gulf of Mexico wells are included in their respective District totals.

These ten newly elected officers

GRAHAM B. MOODY
AAPG President

BYRON W. BEEBE
AAPG Vice President

STUART A. LEVINSON
SEPM Vice President

AAPG-SEPM Hold Annual Meeting in St. Louis

New methods and importance of clay minerals in oil finding stressed.

R. V. HOLLINGSWORTH
SEPM President

NEW EXPLORATION METHODS and the importance of clay minerals in oil finding were the topics of discussion as the American Association of Petroleum Geologists and the Society of Economic Paleontologists gathered in St. Louis for their annual joint convention April 1-4.

The AAPG selected as the theme of its 42nd annual meeting "New Methods and Principles in Petroleum Geology." SEPM members, meeting for their 31st annual session stressed the "Role of Clay Minerals in the Search for Oil."

National authorities in the fields of geophysics and geochemistry as well as geology evaluated the new ideas and methods that are coming into use and appearing on the horizon.

The SEPM program was slightly more technical in content, the papers covering the fields of stratigraphy, paleontology, petrography and geochemistry. These papers have practical applications to daily problems of the professional geologist.

Undersecretary of State Herbert Hoover, Jr., was a scheduled guest speaker at the morning session April 2, following presidential addresses and presentation of honors to outstanding members.

A feature of this year's convention is the field trip guided by members of the Missouri Geological Survey on Friday, April 5, following the meeting. Those making the trip will go to St. Clair, Mo., stopping at exposures of Cambrian, Ordovician, and Mississippian beds.

The Sidney Powers Memorial medal for distinguished service in the geological profession this year goes to J. P. D. Hull of Tulsa, managing editor of the *AAPG Bulletin*. Hull has been with the AAPG National headquarters since 1926.

Honorary memberships in the AAPG have been awarded to T. S. Harrison, Denver; H. P. Bybee, Austin, Texas; J. V. Howell, Tulsa, and E. F. Schramm, Lincoln, Neb.

Award for the most outstanding paper published in the *AAPG Bulletin of Petroleum Geology*, by an author under 35 years of age, goes to Robert H. Parker, Scripps Institution of Oceanography, La Jolla, Calif. The award-winning paper which appeared in the February 1956, *Bulletin*, is entitled: "Macro-Invertebrate Assemblages as Indicatots of Sedimentary Environments in East Mississippi Delta Region".

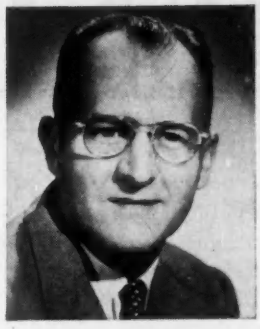
Henry V. Howe, Louisiana State University, Baton Rouge, La., has

will be at the AAPG and SEPM helms in 1957

SAMUEL P. ELLISON, JR.
SEPM Secretary-Treasurer

M. L. THOMPSON
SEPM Editor

PHILIP HENRY KUENEN
SEPM Correspondent



WILLIAM J. HILSEWECK
AAPG Secretary-Treasurer

been elected an honorary member of SEPM. His election brings the Society's total honorary members to four. Prof. Philip Henry Keunen, distinguished Dutch geologist, has been elected a "Correspondent" of SEPM, an honor bestowed on persons not residing in North America who have made distinctive contributions to paleontology, petrology, and stratigraphy that have application to the geology of petroleum.

Recipients of the awards for the best papers in the *Journal of Paleontology* and the *Journal of Sedimentary Petrology* for 1955 include: William R. Walton, Gulf Research and Development Company, Pittsburgh, Penn., "Ecology of Living Benthonic Foraminifera, Todos Santos Bay, Baja California," *Journal of Paleontology,* November, 1955; Louis F. Dellwig, University of Kansas, Lawrence, Kan., "Origin of the Salina Salt of Michigan," *Journal of Sedimentary Petrology,* June, 1955.

The complete list of officers of the two societies is as follows:

AAPG Officers. President, Graham B. Moody; vice president, Byron W. Beebe; secretary treasurer, William J. Hilseweck; editor of the *AAPG Bulletin of Petroleum Geology,* Sherman A. Wengerd. Theo A. Link, president, Cree Oil of Canada, Ltd., Calgary, Alberta, and Toronto, Ontario, is retiring president and will serve with Moody on the 1957-58 executive committee.

Retiring members of the present AAPG Executive Committee are past President G. M. Knebel, manager, Exploration division, Standard Oil Company (N.J.), New York City; Vice President Ben H. Parker, vice president and director, Frontier Refining Company, Denver; Secretary-Treasurer W. A. Waldschmidt, consulting geologist, Midland, Texas; Editor W. C. Krumbein, professor of geology, Northwestern University, Evanston, Ill.

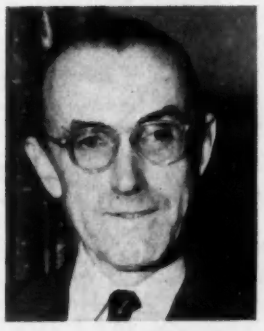
SEPM Officers. President, Richard V. Hollingsworth; vice president, Stuart A. Levinson; secretary treasurer, Samuel P. Ellison, Jr.; editor of the *Journal of Paleontology,* M. L. Thompson; editor of the *Journal of Sedimentary Petrology,* Jack L. Hough. Serving with Hollingsworth on the 1957-58 council will be Robert R. Shrock, Massachusetts Institute of Technology, Cambridge, Mass., as past president.

AAPG President Moody was born in Denver, Nov. 15, 1889. After receiving a B.S. degree in geology and chemistry from the University of California in 1912, he did part-time graduate work at U.C. until 1914. During 1917-18, he was production geologist for the Fuel Oil department, South Pacific Company. He joined California Petroleum in 1918 in the capacity of administrative geologist, remaining there until 1920. At that time he joined Standard Oil Company of California. Moody remained with Standard Oil of California until 1954, and during that time became chief reserves engineer.

Retiring from Standard in 1954, Moody became a consulting geologist with offices in San Francisco and Berkeley.

Moody became a member of the American Association of Petroleum Geologists in 1927. He was secretary of the Pacific Section in 1935, a member of the Research Committee (1945-46) and served on the Committee for Statistics on Exploratory Drilling (1945-56); he was also general chairman of the St. Louis convention (1954), and vice president of the association in 1954.

SHERMAN A. WENGERD
AAPG Editor



J. P. D. HULL
AAPG Sidney Powers Memorial Medal Winner

SEPM President Hollingsworth was born July 26, 1909, in Ellsworth, Texas. After receiving a B.S. and M.S. degree in geology from the University of Oklahoma, he did graduate work in the Department of Geology at the University of Chicago. Hollingsworth's experience includes several years with the Shell Oil Company, Tulsa, and the University of Tulsa before his establishment of the Paleontological Laboratory in Midland, Texas.

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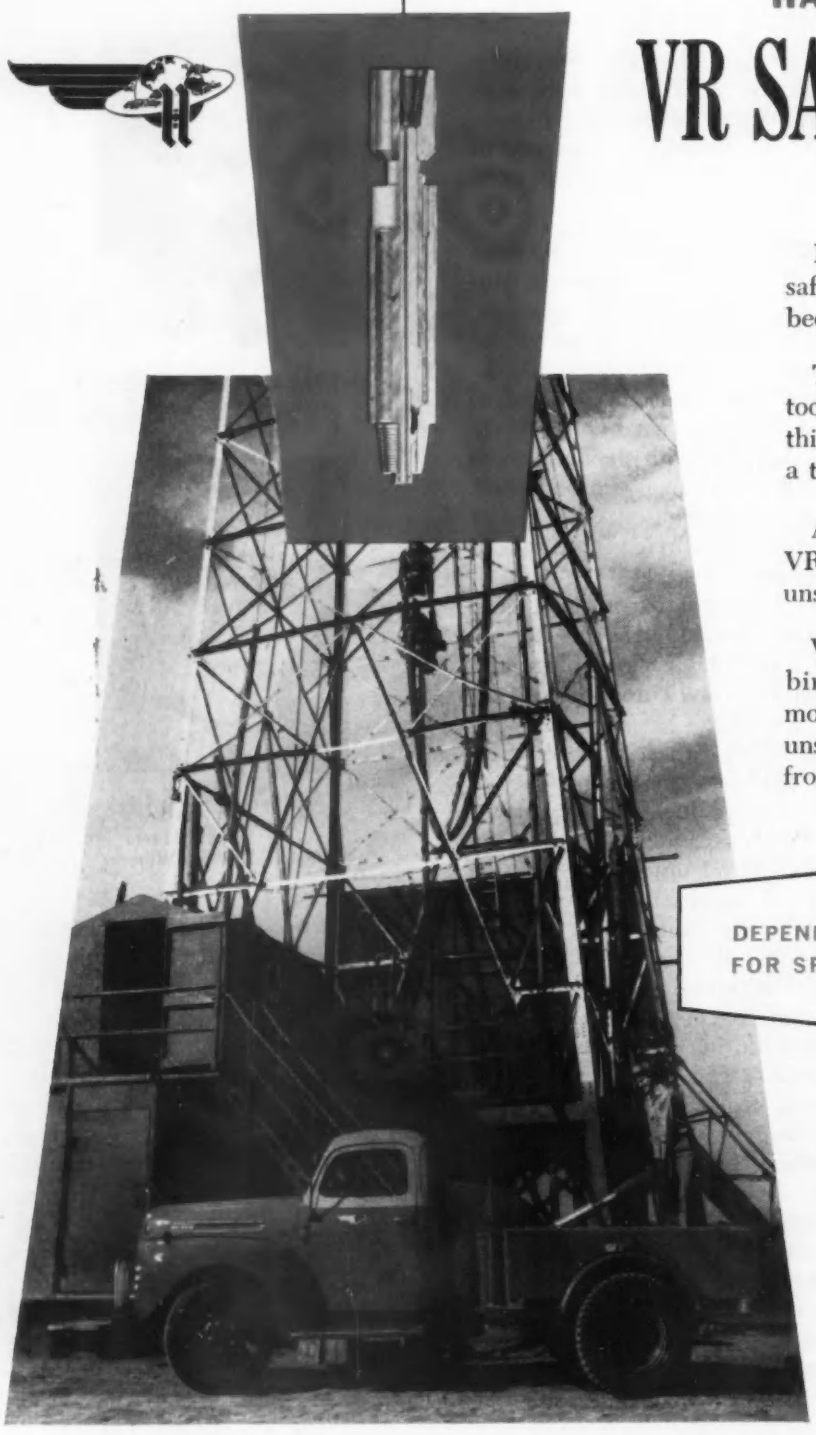

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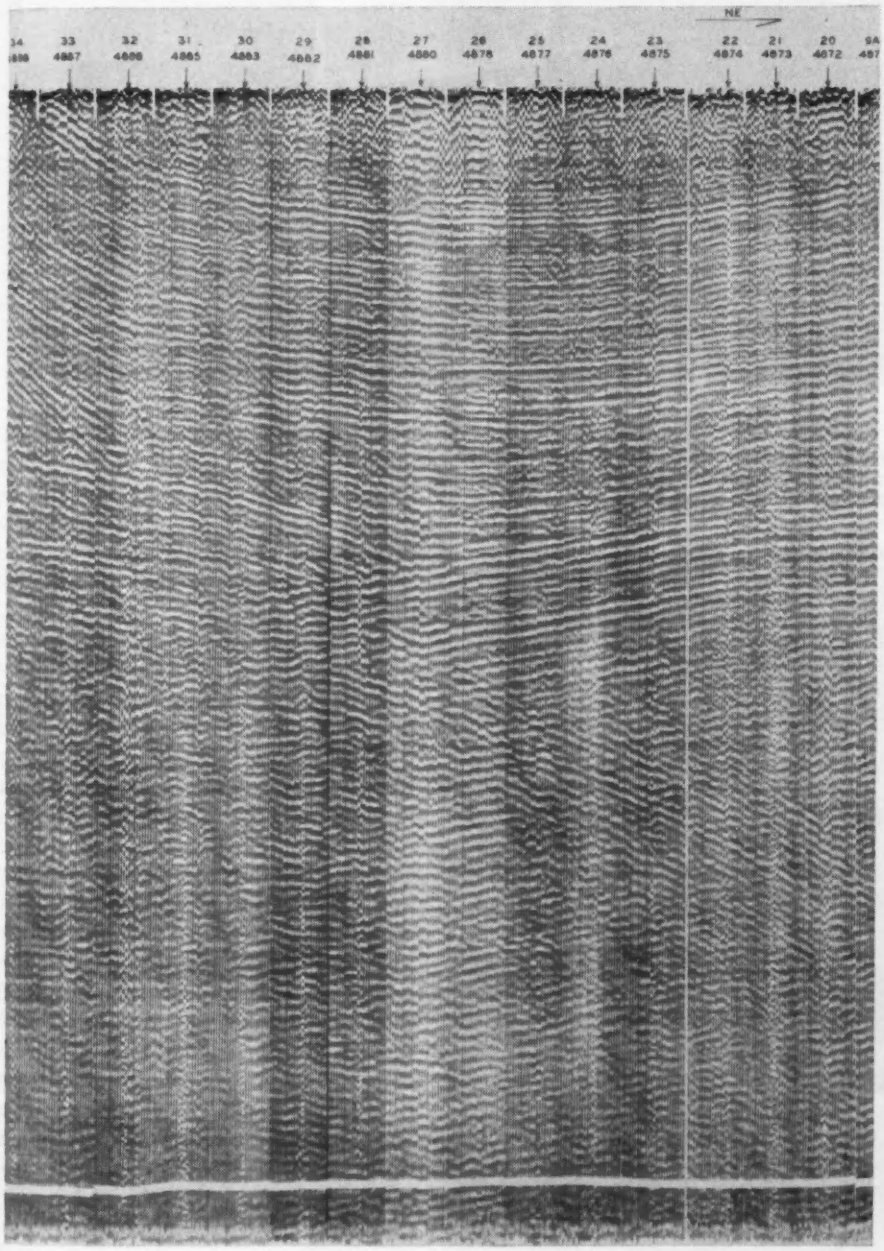
Latest geophysical advances reveal . . .

Magnetic Recording — New Key to Data Interpretation

By GILBERT M. WILSON
World Oil Staff



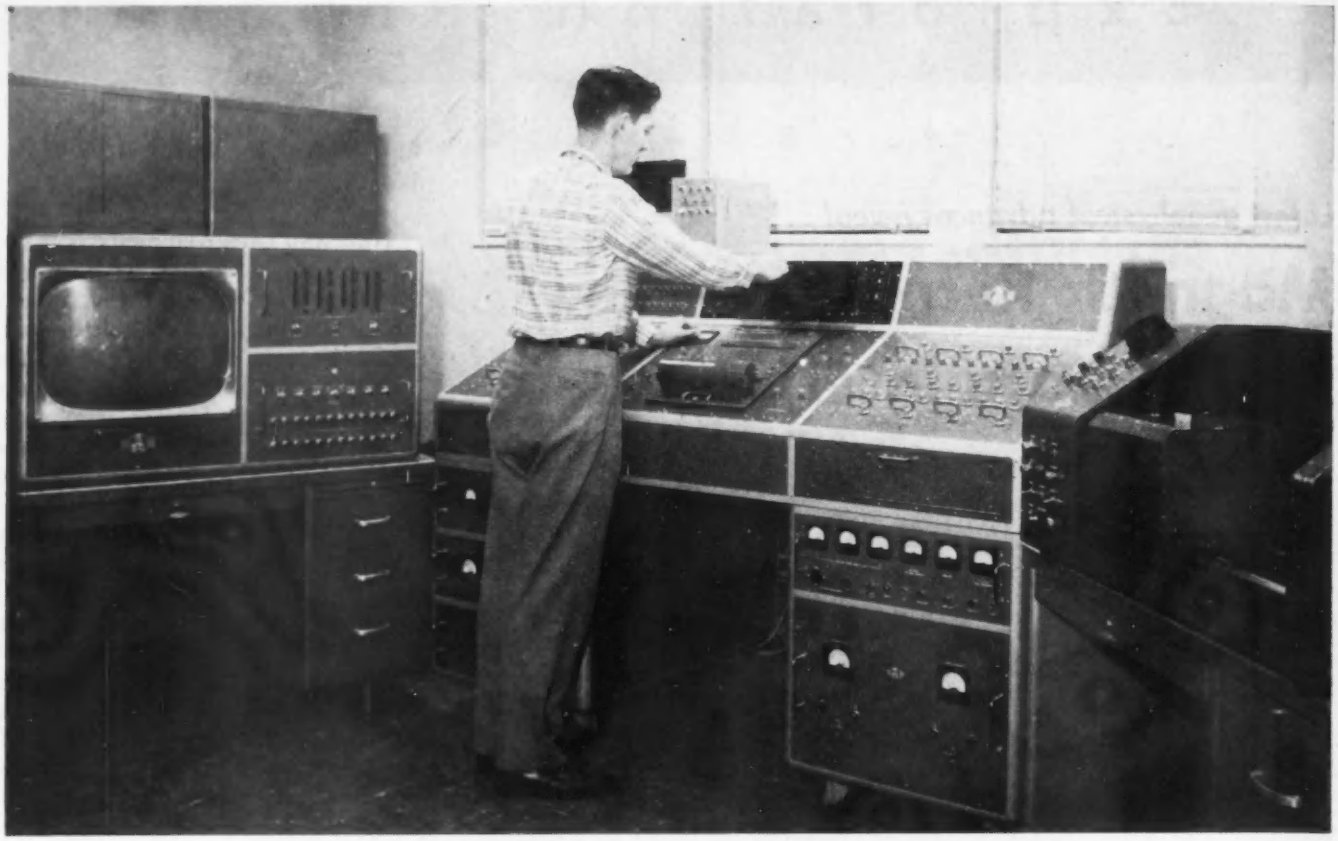
Courtesy United Geophysical Corporation, Pasadena, California

Shown here is a small portion of a typical visual cross section composed of numerous individual records, the reflected energy of the various events being plotted in a manner resembling stratification. Note synclinal structure in upper part of cross section, with apparent unconformity appearing in the approximate center of chart. Using recently developed equipment which automatically corrects individual records for normal move-out, elevation and weathering, the reflected energy of individual traces is taken from magnetic tapes and converted into corresponding light and dark intervals as seen on the cross section.

NEW AND IMPROVED methods of obtaining, recording, playing-back and interpreting of data, coming largely as a result of some recent marked advancements in electronics and research, probably accounted for the greatest share of new geophysical techniques that have emerged into the practical usage stage during the past year or so.

Magnetic recording, in turn, probably can be credited with the principal means through which some of the more notable recent advancements have come forth. Only several years old, magnetic recording of reflection data, originally offered as its initial advantage, the ability to record simultaneously a wide range of usable seismic frequencies which, with the aid of various filters and play-back techniques, could be made to yield far more complete and detailed subsurface pictures. Although initially more expensive than conventional methods, magnetic recording made possible the storing of data for re-examination years later. It premitted re-examination of old records in the light of new subsurface information and/or new developments in play-back techniques without the necessity of re-shooting an area. It is in the realm of play-back and the instrumentation involved that holds great promise of providing a means of still more closely delineating structural pictures. In fact, through use of the record cross-section any person, whether versed in the technicalities of geophysics, a geologist or a layman only slightly acquainted with geology or structural conditions, easily can "see" the formations and their relative position or attitude.

Record Cross-Section of Major Importance. The record cross-section and the recent perfection of automatic recording and data processing equipment that has made it an accurate and extremely practical tool, probably is the most recent, significant development affecting the reflection seismograph. It has done more to bring the geophysicist, geologist and management personnel to a common



Courtesy Seismograph Service Corporation, Tulsa

Engineer makes adjustment in controls of seismic replay center which is used in preparing variable density cross section from individual records recorded on magnetic tape. This replay center consists of a visual display unit, a cross-section camera and a seismic replay console.

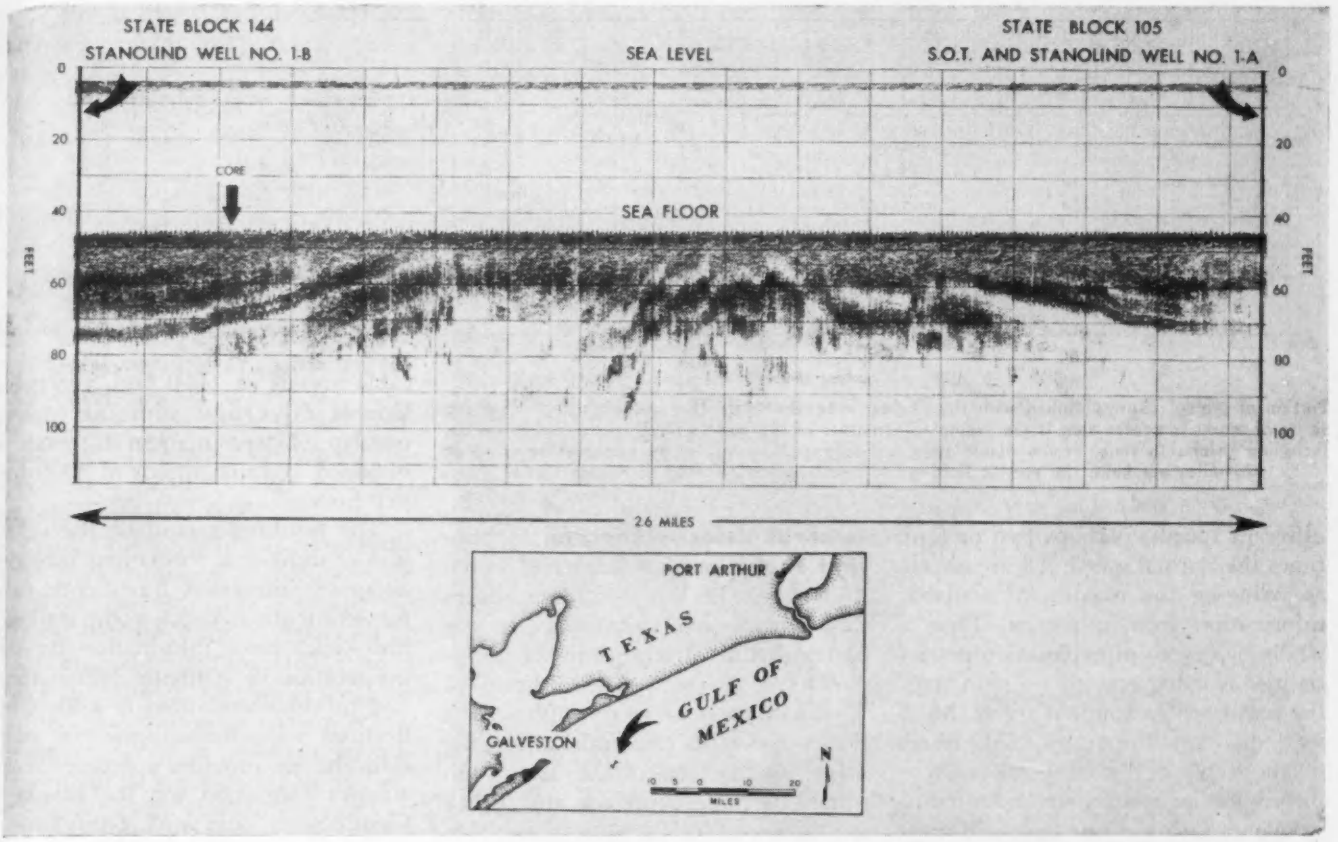
Courtesy Seismograph Service Corporation, Tulsa

This instrument, the continuous velocity log scale converter, was designed especially for continuous velocity logging. It provides valuable information by performing a variety of vertical and horizontal scale conversions while tracking the original field log. Numerous special logs may be obtained by tracking the interval velocity curve of a continuous velocity log. It provides data enabling the geologist and geophysicist to make detailed correlation and porosity studies, positive identification of reflection horizons and numerous other correlations.

level of understanding than has any other single geophysical tool in recent years. In a sense, it has taken the mathematics out of interpreting the results of a seismic survey.

The technique involves the recording, on a single large desk-size sheet, of a visual cross section made up of numerous individual records. Corrected for normal move-out, elevation and weathering—these corrections in themselves representing an important step in automatic processing—the reflected energy of individual traces is taken from the magnetic records and converted into corresponding light and dark intervals on the final chart. Thus, beds which reflect greater amounts of energy, as well as those which do not, appear as contrasting dark and light marks and, when the records are placed side by side to represent a section covering several miles to as much as 20 to 30 miles, structural pictures, unconformities, faults and, of course, regional dips become strikingly apparent to the observer.

It is only within the past year or so that equipment, instrumentation and techniques have been perfected to a point where this unique tool has become generally available. The record cross-section, with seismic data reduced to such an easily interpreted form, becomes a permanent record

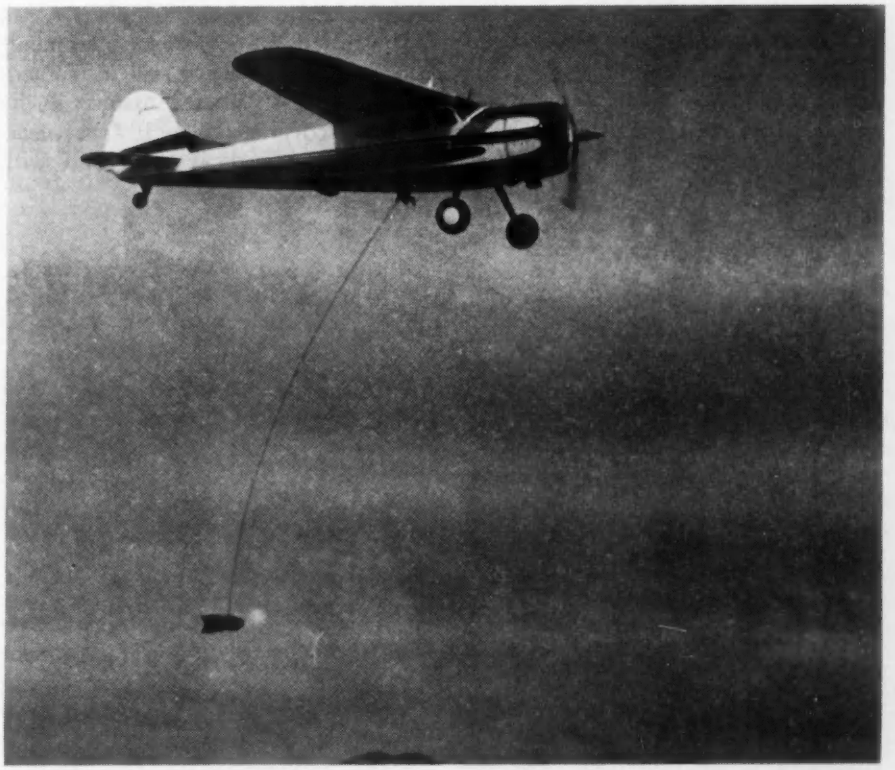


Courtesy Fairchild Aerial Surveys, Inc., Los Angeles

Reproduction of typical profile made of bottom sediments in an area on the Gulf Coast. Note that a truncated anticline is revealed by reflections from the several beds beneath the ocean floor.

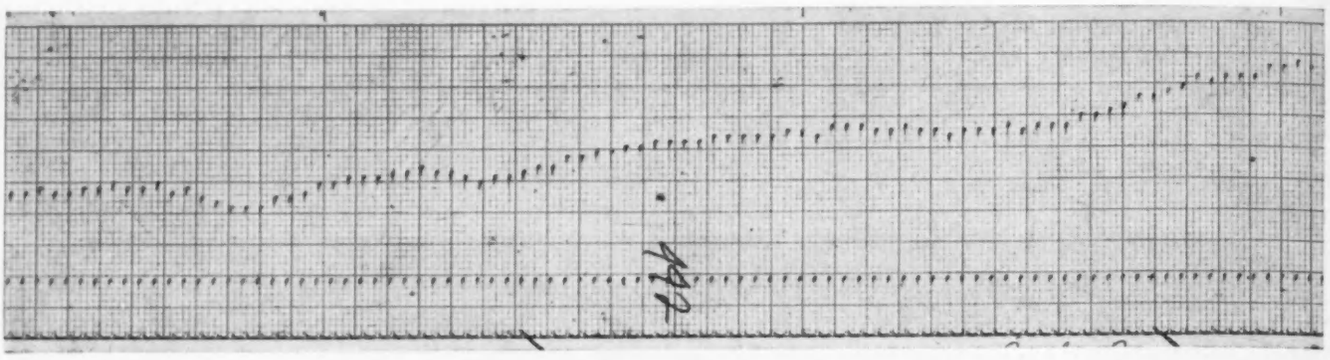
which company personnel can study at leisure long after a survey is completed; a record which quickly can be pulled out and checked against later findings in wildcat or development wells which have a bearing on the over-all picture.

Magnetic recording of seismic data, now believed to comprise more than one-third of all seismic equipment used in the field today, has been instrumental in making the record cross-section possible. When considered in the light that magnetic recording, in the practical field usage form as we know it today, is only 2 or 3 years old, it would not be surprising to expect many new developments—some of them still in the laboratory stage; others still only in the "idea" stage—to come forth in the not-so-distant future. When and if such new ideas are translated into equipment, old records easily can be brought out and re-played to produce possibly new or more detailed "pictures" of a prospected area. As a matter of fact, work is progressing rapidly in the whole field of play-back. Among these techniques are "stacking" of records to cut out unwanted energy and reinforce wanted beds; use of various types of filters to reduce noise; playing records backwards to produce various effects; and playing back at



Courtesy Hycon Aerial Surveys, Inc., Pasadena, Calif.

Weighing only about 80 pounds, this airborne nuclear magnetometer obtains precise measurements of the earth's field using the principle of nuclear magnetic resonance. Sensing element is basically a coil of wire inside a bottle of water. The instrument has no drift and measurements are independent of temperature changes, mechanical shocks and minor power supply fluctuations.



Courtesy Hycon Aerial Surveys, Inc., Pasadena, Calif.

Portion of typical chart obtained with the nuclear magnetometer. The undulating, gently-rising series of marks in center area is the "sampled" measure of the earth's field. Measurement cycles, including polarizing time, occurs about every 0.8 seconds. Carried by an airplane traveling at 120 miles per hour, the earth's field is "sampled" every 140 feet of terrain flown.

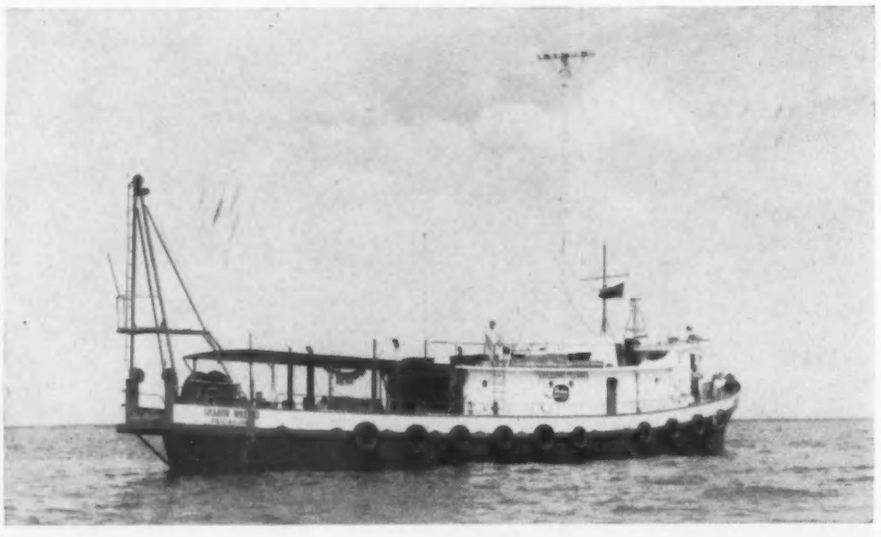
different speeds, perhaps two or four times the normal speed. All are aimed at wringing the maximum available information from a record. That a whole new vista of exploration potentialities is being opened up is to state the matter in its simplest terms. Most immediate and important applications of the new recording and plotting techniques, of course, are to be found in offshore work where boat and crew time is costly and where it is essential that results be processed in a minimum of time. Of great importance, too, is the fact that the newer techniques are releasing geophysicists and seismic computors from the drudgery and time-consuming work of computing records. Time and energy formerly spent on such detail work now can be devoted to other jobs or projects.

Interval Velocity Logging Important Tool. Continuous interval velocity logging also has seen some important advancements, not only in the equipment involved, but in the application of the data derived from it. The tool as now used consists of a device run on a conventional logging cable. At the top of the tool is an ultrasonic pulse generator and, below it, separated by acoustic insulators, are one or more geophones. The pulse generator sends out a sharp, steep-front seismic pulse at regular intervals. The energy, radiating outward and downward through the wall rock, is picked up by the geophones and transmitted to recording instruments on the surface. With one instrument now available, continuous velocity logging coverage over 10-foot measurement intervals is obtained with cable speeds of 6000 feet per hour. Double coverage with 50 percent overlap of measurement intervals is obtained at cable speeds of 3000 feet per hour.

The resulting record of the velocities of individual formations provides accurate, integrated time-depth data for seismograph depth computations; also yields basic information for the preparation of synthetic seismograms and precise correlations of seismic reflections with stratigraphy. In addition, the log provides a detailed, continuous formation log for lithologic identification and well correlation work, the latter supplementing information obtained with conventional electric and radioactive logging instruments. Typical of its application are continuous velocity logging correlations of a group of wells spread across intervals of up to 25 to 30 miles.

Recently, a continuous velocity log scale converter was developed which yields additional information while tracking the original log. It is aimed at making a more positive identification of reflective horizons, studying reflective phenomena as to origin and character, making detailed correlation and porosity studies and making direct correlations with other types of logs taken on different scales. The converter can make these special logs: (1) a log of the velocity on a linear scale; (2) log and film strip of the logarithm of interval velocity drawn versus either time or depth; (3) log indicating seismic reflection travel time from a selected datum to any subsurface depth; (4) log of the average velocity to any depth; and (5) log of the interval velocity in an expanded or reduced velocity scale. This scale converter, incidentally, is not limited only to velocity log data. It may be used to change the vertical and horizontal scales of any logs or plotted data.

Advancements have been made,



Courtesy Western Geophysical Company, Los Angeles

Equipped with the latest in geophysical and navigational gear, this recently-outfitted, 100-foot steel craft was designed with the aim of eliminating vibration and mechanical noises which otherwise would interfere with the operation of some instruments. Shock-mounting the engines and exhausts and installing flexible couplings in the main engine shafts are among the improvements made.

also, in gravity data interpretation. One instrument, an analog gravity computor, employs an optical system which will afford a wider, more effective use of gravity data. The computor produces a synthetic gravity profile from geologic cross-sections, the latter drawn to scale on transparent film. Formations are drawn on the cross-section, the degree of shading representing the density of the simulated formations. The analog computor then is adjusted so that when the cross-section is placed over the reading window, and the meter adjusted, it displays the equivalent gravity response in a manner similar to a conventional gravity meter.

Among the applications possible with this instrument is the ability of the geologist to quickly check the gravity response from an assumed or real geologic condition for, with a pencil and eraser, he easily can modify the cross-section to obtain a new synthetic gravity profile for comparison with field data. In addition, terrain and topographic corrections can be made quickly, permitting the computer to assist in the preparation of gravity field data. The geologist also can simulate the average density of any formation in the earth's crust with accuracy comparable to accepted concepts of geological density distribution and can check the validity of any conventional interpretation of gravity data.

Echo Sounding Device Reveals Bottom Sediments. Of particular value in offshore work is a recent development which gives a remarkably accurate and clear picture of the first 80 to 100 feet of sediment below the ocean floor. The device, which functions very much like a small reflecting seismograph, sends down sound pulses that are generated at rates of from 3 to 12 per second, and at a frequency of about 3800 cycles per second, less than a third the frequency of conventional echo sounders. The sound waves, propogated through the water and into the sediments, are reflected back by the interface between each pair of sedimentary beds that have the necessary contrast in acoustic impedance. The reflected sound waves, picked up by the receiving transducer attached to the side of the boat, are converted into electrical signals and recorded on continuously moving electrosensitive paper. The resulting profile gives a continuous, accurate picture of the structural relations of sedimentary beds beneath the ocean floor.

Surveys taken with this instrument have revealed such phenomena as structure changes, faulting, unconformities, oyster beds, ancient river channels and related information.

This type of survey can be made at a relatively rapid rate and has a number of potential uses in not only geophysics and geology but in engineering such as, for example, the gathering of information relative to bottom sediments necessary for the construction of offshore platforms and submarine pipe lines. Its primary value to the geologist and geophysicist, however, lies in its ability to augment information obtained from cores or other geological data. The device can be mounted on shallow-draft boats for shallow water use, or on larger vessels for use in deeper waters.

Courtesy Fairchild Aerial Surveys, Inc., Los Angeles

Shown here in the retracted position is the receiving transducer of a recently developed echo sounding device which records, to a depth of up to 80 to 100 feet, the sedimentary layers below the ocean floor. Low frequency sound pulses penetrate the shallow beds, reflecting off of the interface of each pair of sedimentary beds that have the necessary contrast in acoustic impedance.

Nuclear Magnetometer Use Expanded. Another tool that has come into common usage only recently is the airborne nuclear magnetometer, a device which uses the principle of nuclear magnetic resonance to obtain precise measurements of the strength of the earth's field. The sensing element of the instrument is basically a coil of wire inside a bottle of ordinary water. A power supply, amplifier, relay system to connect the coil alternately to the power supply and amplifier and a frequency measuring system make up the remainder of the apparatus involved in the unit. Nuclear induction measurements are possible since nuclei possess both intrinsic magnetic and spin angular moments, and thus will precess about a magnetic field, an action that is analogous to the precession of a free-running gyroscope in the earth's gravitational field when an external torque is appplied.

In this instrument the bottle of water serves as the source of nuclei, namely protons. A 100-gauss polarizing field, created by introducing a direct current into the coil, is applied to the water sample at approximately right angles to the earth's field, causing a relatively large percentage of the magnetic moments to line up perpendicular to the earth's field. When the polarizing current is switched off, these moments begin to precess about the earth's field in phase. The precessing proton moments induce an attenuated sinusoidal voltage in the coil at the precession frequency. It is this frequency that actually is measured by the magnetometer. Through an equation, actual intensity of the earth's magnetic field, in gammas, then is determined. In airborne units,

Courtesy Western Geophysical Company, Los Angeles

Greatly speeding up offshore operations is the growing use of floating marine cables. Improved records and, in some cases records where none could be obtained before, have resulted from recently developed pressure-sensitive detectors which are insensitive to wave action or other noise frequencies.

such measurement cycles, including the polarizing time, occur about every 0.8 seconds. This means that the earth's field is "sampled" every 0.8 seconds, corresponding to about every 140 feet for an airplane flying 120 miles per hour.

Aside from the extreme accuracy and lower cost of operation, many advantages are involved in the use of this magnetometer. It measures, in absolute terms, the earth's field, as compared to many essentially gradient measuring devices. It is calibrated on a constant of nature, the gyromagnetic ratio, hence has no drift. In addition, all measurements are independent of temperature changes, mechanical shocks and minor fluctuations of power supply. Important, too, is the fact that the sensing element, the bottle of water, requires no special orientation, an important consideration from the standpoints of both weight of the bird, amounting to only about 80 pounds, and the accuracy of measurement. The polarizing field does not have to be exactly at right angles to the earth's field.

An improvement of the instrument, made within the past several months, was the increasing of the unit's sensitivity by four times through use of a 400 kilocycle oscillator instead of the previous 100 kilocycle unit.

Improved Marine Equipment. During the past year or so a number of improvements also have been made in offshore survey boats and related equipment. Only recently outfitted is the 100-foot all-steel craft operated by one geophysical company. It was equipped with the latest in geophysical as well as navigational equipment, the latter including location-finding gear and radar navigational aids. In order to eliminate vibration and mechanical noises which otherwise would interfere with, or possibly even render inoperative some instruments, the craft's engines and exhausts were completely shock-mounted and flexible couplings were installed in the main engine shafts. It also was equipped with jet hole-digging equipment utilizing high pressure water to jets holes in soft bottom sediments.

Among other geophysical advancements becoming increasingly important during the past year or so was the marine buoyant cable which floats in the water without aid of buoys or floats. The pressure sensitive detector, more completely described as the dual dynamic pressure seismometer, which, unlike the conventional type, is insensitive to wave action or other types of noise, also was contributing measurably to improved marine operations. Graphically illustrating its effectiveness was the job in one area where, with conventional detectors, few if any reflections could be obtained. With the improved pressure sensitive detectors, however, up to 25 to 30 reflections were recorded at each location.

There were improvements, too, in transistorization and minaturization of instrumentation. The printed circuit was finding increased use in certain instruments, aiding in the unitization and handling of equipment in the field. **—The End**

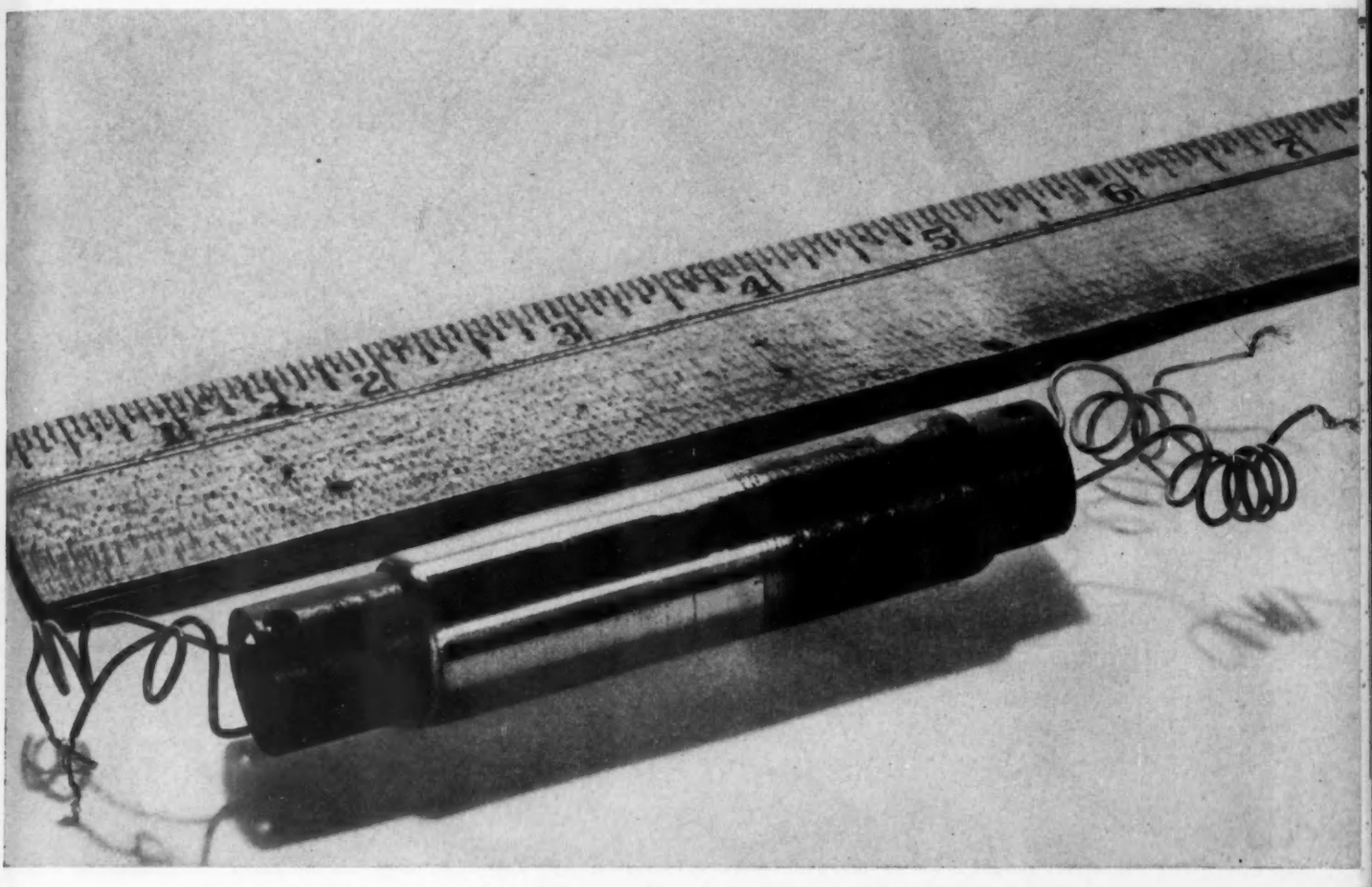


FIGURE 1—This land cable geophone is only four inches long. Weight and diameter are five ounces and three-fourths inch, respectively.

New Geophone Will Improve Seismic Field Production

A new concept in geophone and cable construction designed to provide the geophysical industry with improved seismic production and record quality at a reduced cost per profile mile of subsurface coverage.

By ALAN D. WALDIE
Chief Engineer
McCollum Exploration Company, Houston

RECENT FIELD TESTS of a new land cable geophone, developed by McCollum Exploration Company of Houston, has proven the worth of a unique design which makes practical for the first time a fast system of mechanically planting and retrieving large numbers of geophones and associated cables.

Production has begun on a newly designed small, light-weight, land cable type geophone which, when built into a special cable, can greatly speed up seismic field production. This geophone, shown in Figure 1, is 4 inches long, ¾ of an inch in diameter, weighs about 5 ounces, and generates its own electrical output by the variable reluctance principle. It is attached as an integral part of a cable every 25 feet and is sealed inside a rubber boot for waterproofing. Figure 2 shows the phone as it is attached to the nylon stress member of the cable; the rubber boot, which would normally cover the phone, is not shown. Electrical connections are made by use of "crimp type" terminals.

The idea of placing geophones in cables is not new—offshore exploration crews have been using cable phones now for several years. However, few, if any, attempts at construction of a land cable with geophones which were small, light weight, economical, and "self orienting" had been entirely successful. Gimballed type phones generally are quite tricky and

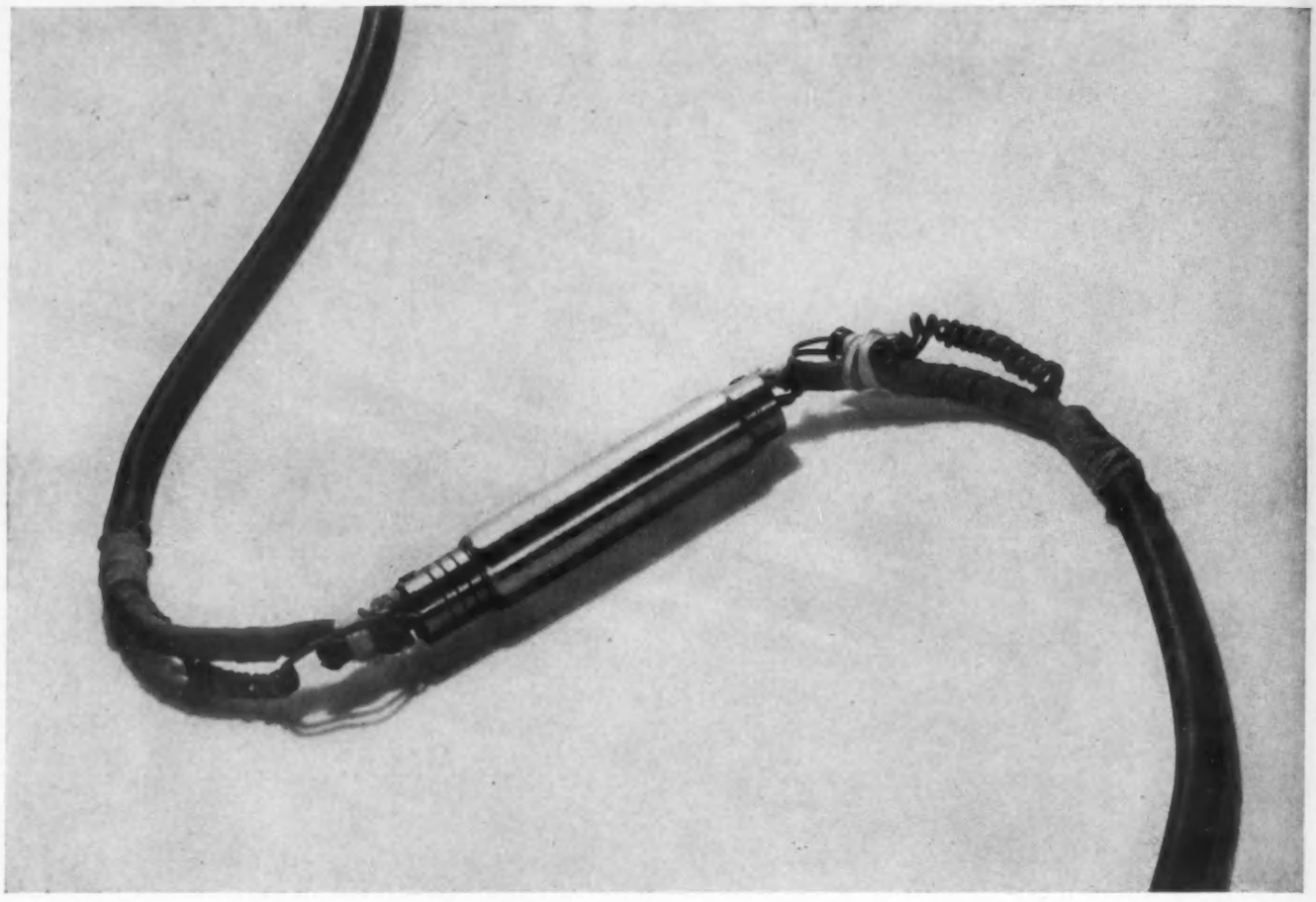
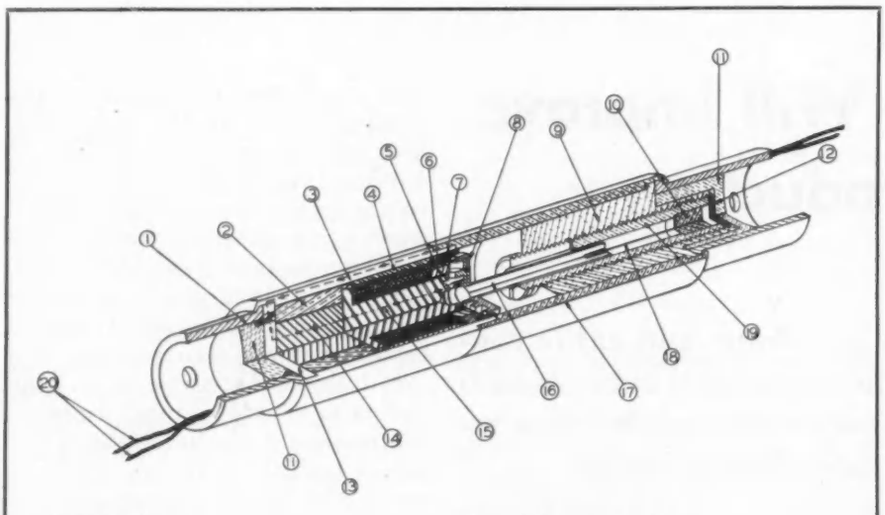


FIGURE 2—Cable phone as attached to special cable. The waterproofing rubber "boot" has been removed.



1 End plugs
2 Case (soft iron)
3 Magnet housing
4 Coil
5, 6, 7 Pole face rings
8 Armature
9 Armature adjusting screw mount
10 Cable anchor
11 Sealant compound (epon resin)
12 Rubber end plug
13 End plug
14 Magnet (alnico V)
15 Coil form base
16 Armature shaft
17 Case end (brass)
18 Armature shaft suspension cable
19 Armature adjusting screw
20 Connecting wires

FIGURE 3—A schematic of the land cable geophone. Successful field tests of these new phones have been completed in the Gulf Coast area and extensive comparison tests are being made in Canada.

require extra space in the phone case for mounting room. Then too, there's the problem of sliding or slip ring electrical contacts from the elements of most phones of this type. Even when these problems are eliminated the comparative size and cost of such a phone become matters to consider when planning the use of great numbers of these on land.

Unique Principle. This new geophone, which has just been developed, operates on the variable reluctance principle without gimballs in a rather unique manner for geophone construction. A look at Figure 3 will illustrate the phone's components in a "cutaway" drawing. The major parts of this phone are the alnico V magnet (14); the soft iron coil form (15); the coil (4); the armature (8); and the armature shaft suspension cable (18).

The magnetic path can be traced from the right end of magnet (14) through the coil form (15) across the air gap to the soft iron armature (8)

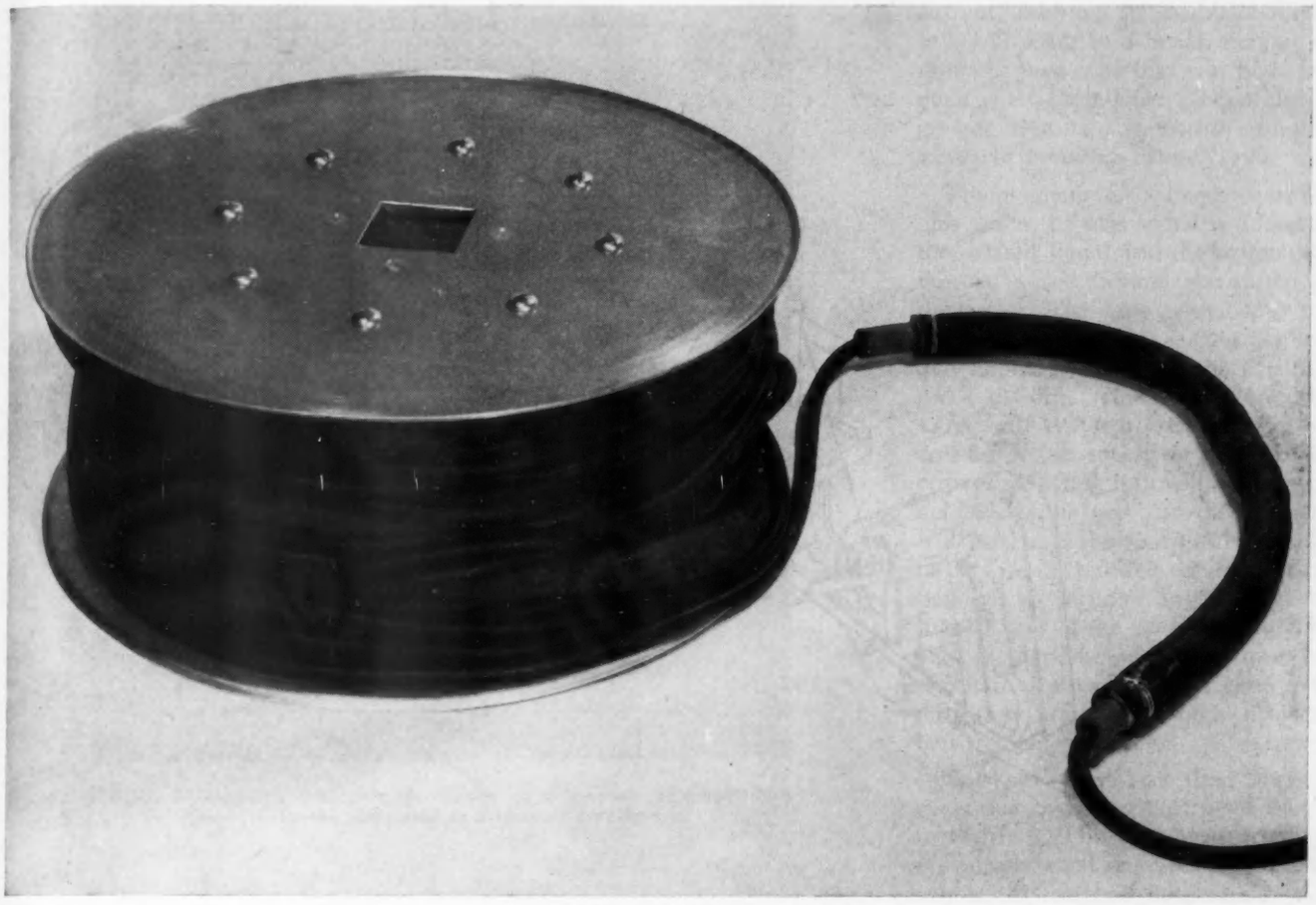


FIGURE 4—Cable phone complete with cable, reel and waterproof "boot." Weight: 35 pounds, Length: 330 feet of cable, Number of phones: 13 spaced 25 feet apart.

up through the armature and back across the air gap to a soft iron ring (6). From this ring (6), the flux path travels along the iron case (left half #3) to the iron end slug (13) and then to the left end of the magnet (14). The concentric rings of the armature match like rings in the pole face of the coil form (15). Magnetic force lines across the air gap center the rings of the armature in line with those of the soft iron coil form pole face through an air gap of about three-thousandths of an inch while holding the armature shaft suspension cable (18) under tension. In a steady state, an unchanging magnetic field surrounds the coil (4) in all directions. This magnetic field will vary only when an outside force, or vibration, perpendicular to the horizontal axis of the phone is received. These vibrations, which are received as the seismic waves, move the armature from its center position increasing the air gap between the pole face and armature. This increase in air gap changes the magnetic field around the coil and induces a changing current in the coil windings to produce a voltage change (representing the seismic signal) for amplification and recording.

Rugged Construction. The construction of a phone of this nature can be kept relatively simple—yet sufficiently rugged and sensitive for its size. It is considerably more rugged than conventional land phones since it contains no springs or "spider webs" to weaken or break. In effect, it has a magnetic "spring" for its action because the armature face is suspended by magnetism. The only component which could break is the flexible cable (18) which holds the armature shaft. However, this cable is made of 15 pound test seven strand beryllium copper wire and has proven to be quite satisfactory for this purpose.

Frequency Adjustment. Referring again to Figure 3, the armature adjusting screw (19) is used during final checkout of the phone, before it is damped, to adjust the frequency and output. The frequency of each phone is set to 25 cycles per second—at undamped peak resonance. However, the phone has been designed so that its frequency can be set during assembly to higher or lower frequency values according to the need.

Two methods of damping have been utilized in this geophone—namely magnetic and viscous damping. The magnetic damping is inherent with the magnetic suspension of the armature. Viscous damping is achieved by filling the chamber surrounding the armature assembly with a light silicone fluid. Silicone fluid is used because its viscosity remains substantially constant over a wide temperature range.

Sensitivity. The sensitivity of this phone as compared with the regular small conventional geophone is somewhat less than the latter since it was felt that some sensitivity could be sacrificed for size. It has been found that in areas where large numbers of phones per station are required, the sensitivity should be realized from the whole group of phones—*in diversity*—contributing to this station rather

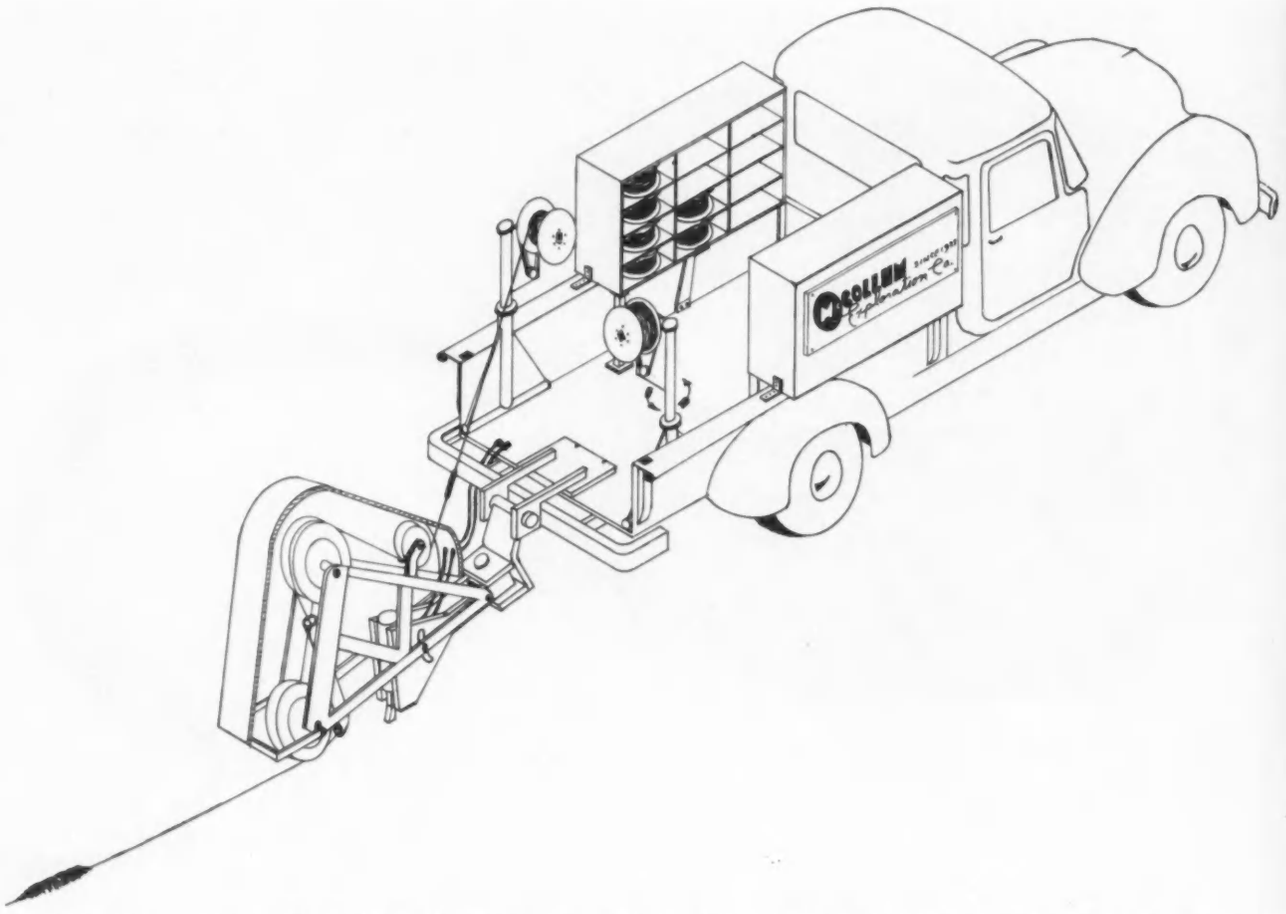


FIGURE 5—Artist's concept of geophone planter. Speeds up to eight miles per hour can be obtained by using this device with land cable geophones.

than by a smaller group of phones which are individually more sensitive. This is quite easily explained. In the first place, where large numbers of geophones are used in arrays for cancellation of undesirable signals—such as surface, and/or near surface energy —all phones are contributing to the group-per-station for the cancellation effect desired. If highly sensitive individual phones were used, it is probable that local disturbances near parts of large arrays could tend to obliterate the entire output of the array. Now, if less sensitive individual geophones were used in a series-parallel arrangement—spread in diversity over the station area—the desired cancellation effect of the array should be obtained with less trouble from local disturbances around parts of the group.

Hookup. The size of the phone has been kept to a minimum so that a number of these installed in cables could be wound on small lightweight reels. Figure 4 is a photograph of one of these reels which contains 13 geophones hooked in series at 25 foot intervals for a total length of 330 feet. This reel, complete witht phones and cable, weighs only 35 pounds, is 16 inches in diameter and 6 inches high.

Mechanical Planting. In areas where terrain permits the use of mechanical planter, as shown in the artist sketch (Figure 5), speeds of from five to eight miles per hour can be obtained in laying out and planting these cable detectors. The pickup truck shown pulls the planting attachment which digs a trench for the phone pod, squirts a small amount of water in the trench for good phone-to-ground contact, and then rolls the phone into the trench which is dug automatically for each phone. Since only the portion of the cable which contains the phone is buried, the trench is dug about 2 feet long, 1½ inches wide, and 1½ inches deep.

When it becomes necessary to plant these cable phones by hand it will be found that this cable phone method is still quicker than laying by hand conventional phones which have to be attached to their lead-in lines. The reel which holds the cable and phones can also be placed on a breast reeling unit which one man can easily carry while walking or crawling into a difficult area to plant these cable phones by hand.

Field Tests. Successful field tests of these new phones and cables have been accomplished in the Gulf Coast —while extensive comparison tests are now being made with 700 of these cable phones in Canada. Plans are now being completed to field test some 2000 of these new geophones and cables in "difficult record areas" of West Texas this spring.

The main goal of this new concept in geophone and cable construction is to provide the geophysical industry with a new system of field techniques which can improve seismic production and record quality while it reduces the over-all costs per profile mile of subsurface coverage. —**The End**

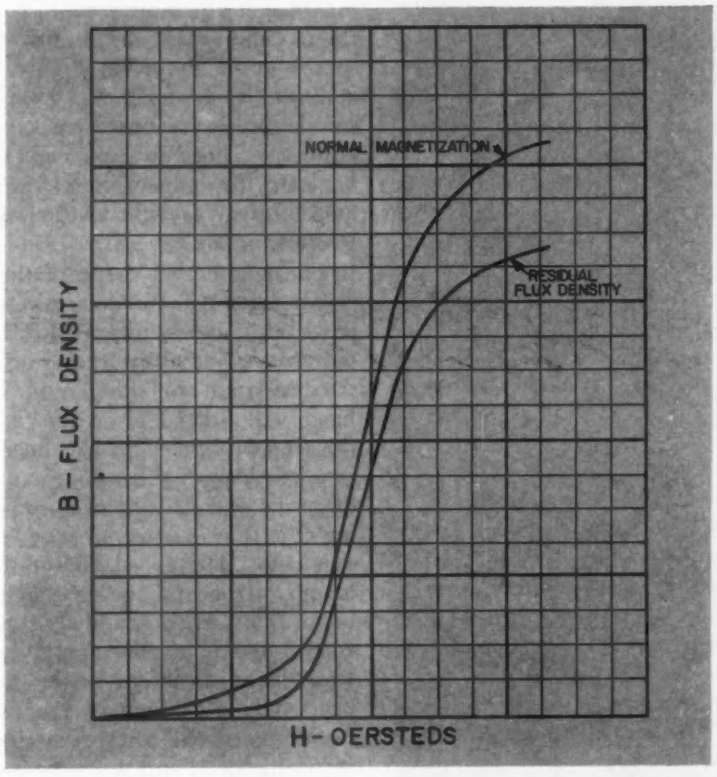


FIGURE 1—Magnetic induction (B) plotted as a function of magnetizing force (H) for the oxide used on magnetic recording tape.

New Developments Made In Direct Recording Heads

Experiments indicate that the rounded head with mu-metal laminations inside and outside a mu-metal container produced the optimum pulse response and lowest cross talk level combined with ease of manufacture.

By A. S. BADGER
Southwestern Industrial Electronics
Bellaire, Texas

THE PROCESS of investigating new design possibilities for low frequency direct magnetic recording heads uncovered a number of scientifically interesting problems. Of principal concern was good transient reproduction in playback and minimum crosstalk between recorded channels. In addition, the effect of different head lengths on frequency response was investigated and the results recorded.

Figure 1 shows magnetic induction (B) plotted as a function of magnetizing force (H) for the oxide used on magnetic recording tape. The upper curve is the normal magnetization curve. The lower or residual flux density curve is drawn by establishing various intensities of magnetization in the oxide, reducing the external field to zero and plotting the resulting flux values. For a given intensity up to the instep of the curve there will be very little remnant flux in the tape.

As a consequence, bias must be used so that the recorder will operate in the linear portion of the curve. In this portion, an increase of recording current, reflected in magnetic intensity, will result in a linear increase of remnant flux. The bias is a high frequency AC component, equal to or greater than the intensity required to reach the instep of the curve.

The magnetic recording process begins when the bias signal is added to the desired signal and the magnetization is moved beyond the instep of the curve. The tape passes over the recording head at 7½-inches per second and as soon as the bias field is reduced to the value at the instep the signal will be recorded. If bias is increased to an excessive amount, the critical recording flux will not be well defined by the gap and the gradiant will no longer be sharp. This results in frequency sensitive de-magnetization due to variation in the magnetization curve of the oxide coating. The bias is therefore a compromise between that amount which gives least distortion and that which provides best frequency response.

The necessary recording flux is generated by a ring type head shown in Figure 2. This type head, which is universally used in direct recording, consists of two half laminations with a non-magnetic material providing an equivalent air gap between the laminations at the point of contact with the tape. There is a winding on each half lamination and the heads are ground so that approximately one-eighth of an inch of core length is in contact with the tape. A gap length of one mil is chosen to make the gap length short in comparison to the wave length on the tape and to reduce necessary recording current. The enlarged gap, illustrated at the bottom of Figure 2, shows the flux distribution at the air gap and in the tape adjacent to the air gap. The fringing flux which extends 5 or 6 gap lengths out and around the air gap is the effective recording flux.

The shape of a direct recording head ordinarily has a detrimental effect on transient response. This is due to the characteristic of the end of the head anticipating the recorded signal and prematurely inducing voltage in the core. (See Figure 3). Transient response is important for reproduction of time break and first returns where a sharp leading edge is necessary to establish the time of the waveform beginning. Several experimental heads were tapered back at constant angles from the tangent to the tape

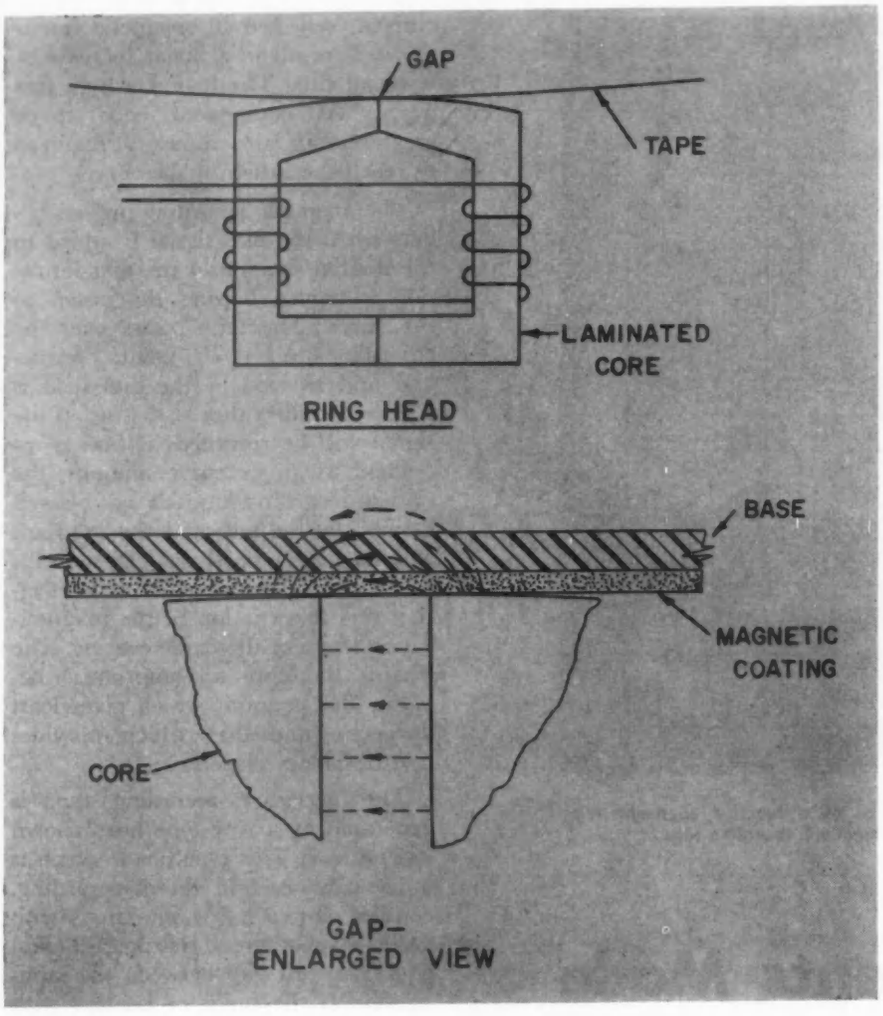


FIGURE 2—Recording flux is generated by a ring type head shown above. The enlarged gap shows the flux distribution at the air gap and in the tape adjacent to the air gap.

mounted on a cylindrical drum.

Figures 4 and 5 are oscillograms of a 10-millisecond pulse which show the response of these experimental heads. The downward dip on either side of the peak is in the opposite direction to the proper signal flux. Upon examination of the timing lines on the oscillogram, these dips were found to be exactly half the width of the head. This indicates that this effect is induced by the edge of the heads. This dip has been called the leader effect. The 30-degree head virtually eliminated the transient effect but still did not give a sharp time break.

The eight-degree head was then modified by grinding to a 13/32nd radius and gave the improved response curve shown in Figure 5. An angular head which also gave a desirable pulse response was made by cutting a head at an eight-degree angle to the tangent of the tape and at a 45-degree angle to the width of the tape on a bias.

The length and shape of the head is also critical in determining the playback response of the head. Certain wave lengths, depending upon their relation to the length of the head, will either add or interfere with the signal induced in the head. The response curve will contain a series of peaks and valleys when approaching the low frequency end of the spectrum. These are caused by the length of the head being equal to integral half wave lengths of the recorded signal on the tape. When the wave length becomes longer than the head only a portion of the flux between poles will enter the magnetic recording head and the response curve will slope off to zero. The frequency response in playback of these experimental heads is shown in Figure 6. Note that the dips and valleys, which occur approximately every 15 cycles, are very pronounced in the eight-degree head but diminish in the round and angular heads.

Cross talk is predominant in the

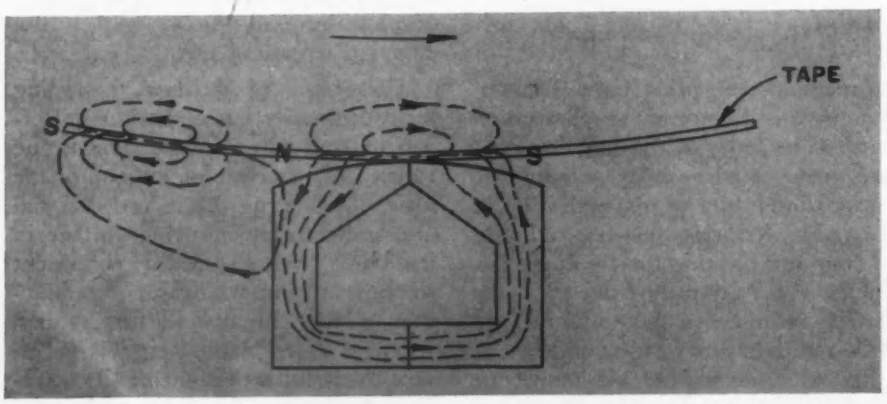


FIGURE 3—Flux paths. The shape of a direct recording head ordinarily has a detrimental effect on transient response. This is due to the characteristic of the end of the head anticipating the recorded signal and prematurely inducing voltage in the core.

About the Author

ALGERNON S. BADGER, who is presently a project engineer with Southwestern Industrial Electronics Corporation, received his B.S. in Electrical Engineering from the Rice Institute in 1948. He was graduated with an M.S. degree in Electrical Engineering from Rice in 1949. Until his employment at SIE in 1956, Badger worked for Consulting Engineers in the Houston area. He is also a lecturer in Electrical Enginering at Rice.

seismic range of 15 to 500 cps where the wave lengths are long in comparison to the recorded track width. These long wave lengths will allow flux to fringe out in all directions around the tape causing cross talk between channels. Figure 7 is the cross talk level between a 13/32nd-inch radius rounded head and the signal recorded on a channel adjacent to it. These curves were obtained by recording on one channel and playing back from the adjacent channel. No signal was recorded on the playback channel.

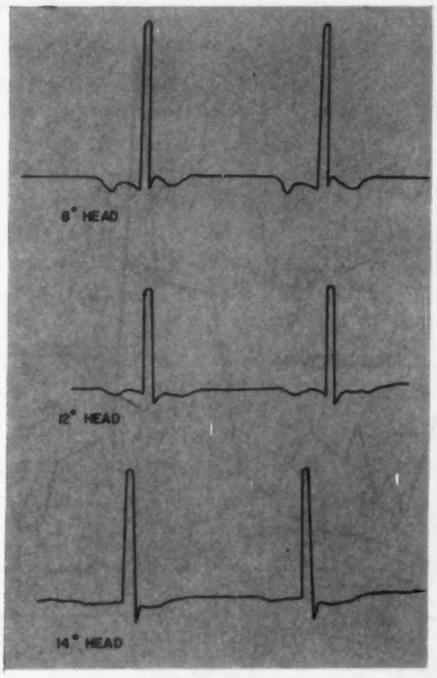
The db levels shown are levels down from the playback curves of Figure 6. The upper curve is for a shield composed of a mu-metal can surrounding the recording head. With the addition of a mu-metal lamination soldered to the inside of the can on either side of the head, the level was reduced by approximately 6 to 8 db.

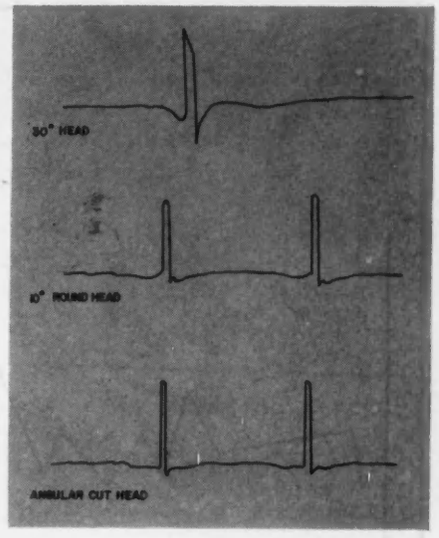
Further reduction is obtained by soldering mu-metal laminations on the outside of the can. The contouring of these mu-metal laminations to the drum produced a slightly better cross talk curve below 12 cps. However this slight difference between the flat mu-metal can and the contoured can was not enough to warrant additional cost of manufacture. Other experiments with mu-metal included placing the mu-metal strip under the tape which resulted in cross talk being below the noise level at all frequencies measured.

Poor transient response resulted, however, due to the flux being attracted by the mu-metal backing under the head. As the flux approached the air gap it transferred very rapidly from the mu-metal under the tape to the head creating a large leader. In another case a flat mu-metal strip was contoured to the drum diameter with an opening to allow the head to protrude so that the mu-metal and recording head were in intimate contact with the tape. This shielding produced a low cross talk value but presented too difficult a problem in manufacture.

From these experiments, it was determined that the rounded head with mu-metal laminations inside and outside a mu-metal container produced the optimum pulse response and lowest cross-talk level combined with comparative ease of manufacture.

—The End





FIGURES 4 and 5—Pulse response. Oscillograms of a 10 millisecond pulse which show the response of experimental heads.

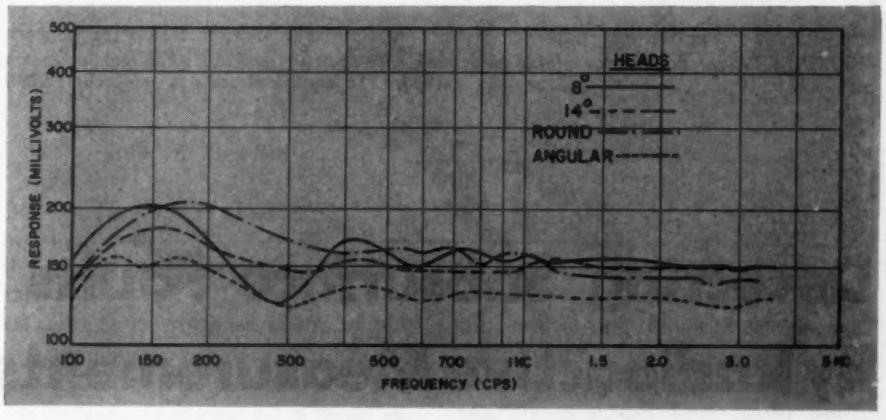


FIGURE 6—Frequency response (7.5 inches per second) in playback of the experimental heads. Note that the dips and valleys which occur approximately every 15 cycles are very pronounced in the eight degree head but diminish in the round and angular heads.

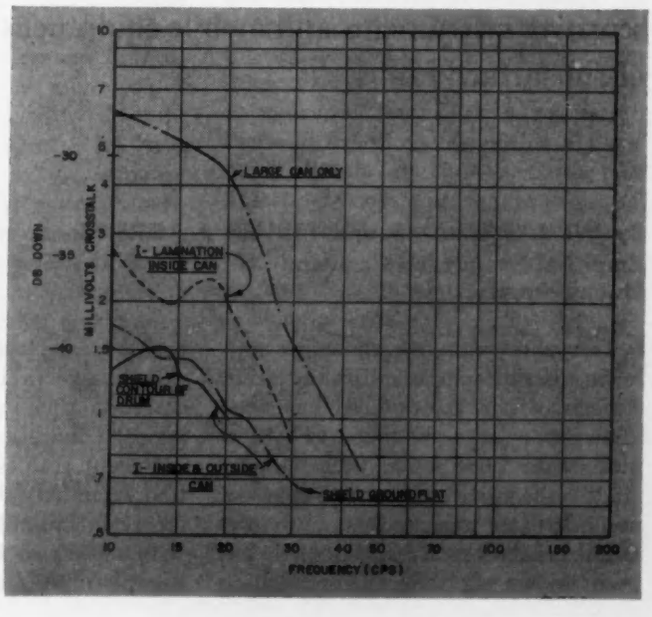


FIGURE 7—Cross-talk level between a 13/32 inch radius rounded head and the signal recorded on a channel adjacent to it. These curves were obtained by recording on one channel and playing back from the adjacent channel.

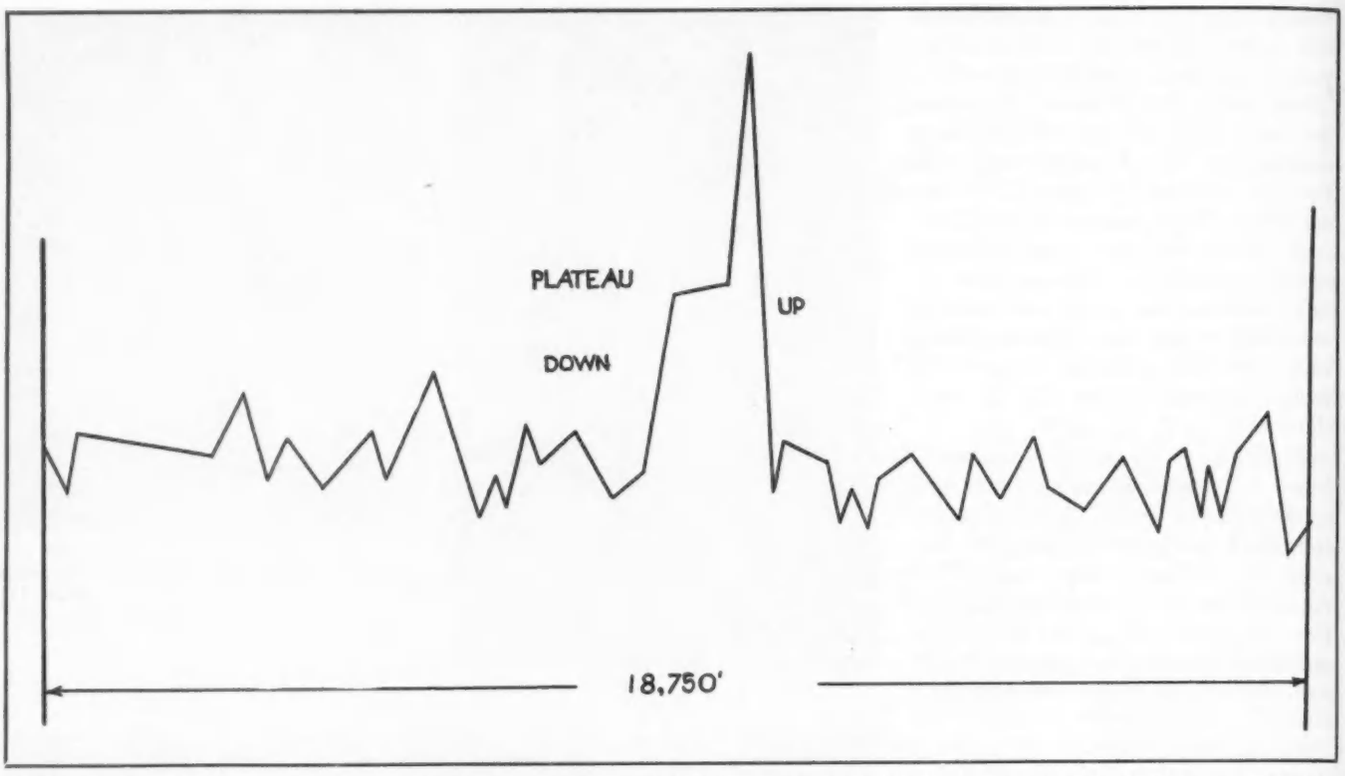


FIGURE 1—Typical gamma ray profile associated with faulting recorded while mobile reconnaissance equipment traversed the areas at 20 miles an hour. The horizontal scale is one inch to 2000 feet.

Detecting Subsurface Faults By Radioactive Measurements

Surface gamma ray surveys made with highly sensitive instruments and mobile equipment reveal evidence of subsurface faults.

By W. J. WILLIAMS and PHILLIP J. LORENZ
Empirical Exploration Company
Owensboro, Ky.

THE EXISTENCE of radioactive matter in the lithosphere and the adjacent regions of the atmosphere has been known for over 50 years. Furthermore, over continental areas, terrestrial radioactivity is responsible for much greater ion production than is cosmic radiation. Even though it has been known that the earth radiation varied from place to place, only a few efforts have previously been made to correlate this information with geological conditions.

Recent studies with special ionization chambers show a significant increase in radiation above fractures in sedimentary rock structure. Although there is usually a loss of radiation intensity in areas where the fault is covered by extreme depths of overburden, this increased radiation activity is in marked contrast to the random background radiation in surrounding areas. The effect was first noticed in places where fault conditions were observable at the surface. Later, and in numerous cases, when radiation patterns indicated faults, but without surface evidence, test drillings have amply confirmed their existence. Faults have been located at depths as great as 5000 feet below unfaulted strata.

There is considerable evidence to indicate much of this surface radiation originates from the upward migration of radioactive gases through porous sedimentary strata.

Basic Radiation Characteristics of a Fault Zone. An increase in radiation intensity in a fault zone might be expected from the deposition of radioactive minerals by ground water in such a region. Furthermore, fracture and fault fissures in a fault zone will allow migrating radioactive gases to change direction in seeking the least line of resistance to the surface, whereas they might otherwise have

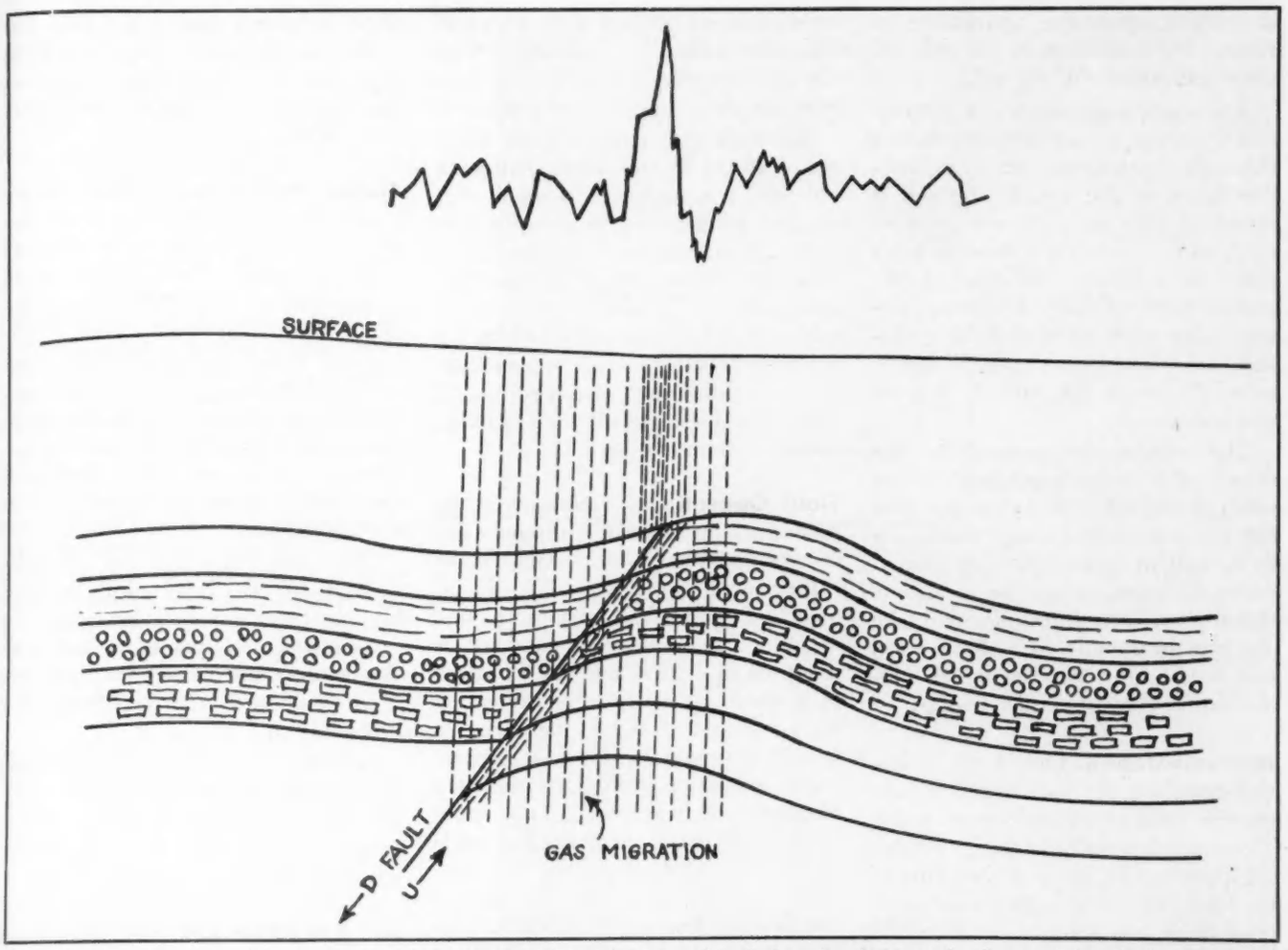


FIGURE 2—The upward migration of radioactive gases shown through surface faulting in relation to the characteristic radiation profile.

diffused more or less vertically through porous sedimentary rock strata.

In Figure 1 it will be noted that as the survey vehicle moved northward (left to right on graph), only random, background gamma radiation was detected. Then a plateau region of moderately high activity was reached approximately 750 feet south of the point of maximum radiation intensity. This plateau is characteristic of the downthrown side of a fault. Here the vertical migration of radioactive gases is unhampered by the fault fracture and is reinforced by gases diffusing upward from the fracture. On the other side of the radiation peak a point of minimum radiation intensity may be observed.

This is characteristic of the upthrown side of the fault. Figure 2 illustrates the type of subterranean structure that might account for this phenomena. Considering the angle of fault fracture, most of the gas which migrates into the fracture will follow it to the surface and give intense radiation at the point where the fracture is nearest the surface, and at the same time, produces the extremely low intensity noted on the upthrown side of the fault.

Hundreds of faults have been detected and studied by the gamma ray survey method. Nearly all show this characteristic radiation pattern.

Radiation Characteristics of Other Structures. Basically, any subsurface unconformity or variation in porosity may affect the vertical migration of radioactive gases and thus alter the surface radiation pattern. In cases where rock density in an anticline structure has increased with a corresponding decrease in porosity, as a result of folding, there will be a decrease in surface radiation. Other observers have noted a decrease in gamma radiation above oil reservoirs. Recent surveys have not, in general, confirmed such observations.

Apparently, a radiation low occurs only when an oil pool lies below very high density (and non-porous) anticlinal strata. Since such dense strata are not necessarily associated with oil, this prospecting technique is not as useful as it was once believed. In fact, high radiation intensity patterns have been noted over some fields, especially where multiple horizons contain oil.

Surface Radiation. It must be emphasized that the major source of radiation detected in these surveys is the radioactive material in the upper six feet of earth. Since this material is normally leached out by water, there must be some agency of replacement. Nearly all constituents of the lithosphere contain uranium, thorium, and their decay-products. On the average, the radioactive content of igneous rock is about twice that of sedimentary rock.

The radioactive substances found in the atmosphere are chiefly radon, thoron, (both gases) and the products formed by their disintegration. It is believed (see "Terrestrial Magnetism and Electricity," edited by J. A. Fleming of the Carnegie Institution for Dover Publications, 1949) that this material diffuses into the air at a rate

dependent upon the abundance of radioactive substances in the soil and upon the porosity of the soil.

The wind, and changes in pressure and temperature, are probably factors that affect the discharge of radioactive gases to the air. If the soil is saturated with water, frozen, or covered with snow, the diffusion takes place at a slower rate than if the ground were exposed. In recent surveys it has been noted that the radiation is reduced over paved roads, especially when the asphalt is fresh and non-porous.

The radioactive material in the upper soil is probably the result of the upward migration of radon and thoron gases through porous underlying strata and/or deposition from ground water. It seems reasonable to assume that such gaseous diffusion would take place more rapidly in a fault zone, and it is known that increased mineralization occurs in such regions.

Instrumentation. Only large ionization chambers of a special design have proven satisfactory in survey work. These instruments have steel, cylindrical chambers of unusual size. One of the larger chambers, which is mounted on a truck, has a volume of over 350 liters. The chambers are filled with an inert gas to a pressure of about 30 atmospheres. Under these conditions the ionization produced in the chamber is nearly fifty times greater than in an equal volume of air at normal pressure. This design enables the instrument to detect large quantities of radiation even when the rate of travel of the equipment ranges from 20 to 40 miles per hour. This sensitivity, plus a rapid response, insures the necessary statistical accuracy.

The ionization chamber is mainly a detector of gamma rays. Because of the thickness of the walls, alpha or beta radiation will rarely penetrate into the chamber, but high energy cosmic ray particles will occasionally produce a burst of ionization.

The gamma radiation detected in surface surveys is from three main sources.

- The radioactive substances in the soil.
- The radon and thoron gas decay products in the atmosphere which emanate from the earth.
- Cosmic radiation. Additional ionization is produced by radioactive impurities embedded in the steel chamber walls. The radiation from the soil, however, is more intense than from all the other sources combined.

Although radon and thoron are a major factor in the accumulation of radioactive materials in the soil, they emit no gamma rays (only alpha particles). Their decay products, however, are rich sources of gamma rays and probably constitute the major part of the radiation detected by the ionization chamber. Two of the decay products, Radium *C* and Thorium *C*, emit the most penetrating gamma radiation observed.

Field Operations. Field surveys by mobile reconnaissance equipment are usually undertaken to determine if the subterranean structure in a particular area is favorable for the production of oil. The ionization chamber is mounted in a truck and the variation in gamma radiation is registered on an automatic recorder, the chart of which is driven by the speedometer cable. Radiation profiles are recorded along several transversals at a speed of about 20 miles per hour. The angle at which a fault is crossed has considerable influence on the character of the profile. The most indicative pattern is produced when the fault is crossed at right angles as was the case in Figure 1.

The operating geologist repeats all significant runs and notes surface conditions that might affect the radiation graph. The consistent duplication of data on repeated runs emphasizes the reliability of these techniques. Although there will be minor background variations because of the random nature of radioactive disintegration, a characteristic fault profile will be unmistakably clear no matter how often, or when, or in what direction (backward or forward) a particular survey run is recorded.

In field experiments it has been noted that transversals run late at night produce profiles with a greater differential than those recorded during the day. The amplitude of a gamma ray intensity peak taken during the day may be tripled in a night survey. This effect has been attributed to temperature changes in the soil. The radioactive gases present in the soil diffuse into the atmosphere and are dispersed more rapidly as the earth is heated during the day. The cooling of the soil at night would be expected to reduce this emanation, thus leaving more radioactive matter at the surface.

Surface Variables. Certain surface conditions may distort the radiation profile. When the survey vehicle passes a cutbank there is usually an increase in intensity from the radioactive sources in these surfaces. The gamma radiation over paved roads and bridges is significantly decreased. Areas where water has accumulated from recent rains or flooding cause a similar loss of intensity. Erosional variations may also influence the radiation pattern.

Obviously, large deposits of radioactive material will be readily detected by the ionization chamber. Also, an occasional cosmic ray burst will drive the recorder off scale, but this occurence would rarely be duplicated in a repeated run.

Although none of these variable factors produce the characteristic profile associated with faulting, trained personnel is required for both the recording and interpretation of data.

Air Reconnaissance. Low-flying helicopter operations should greatly decrease the time required for extensive gamma ray surveys, especially in inaccessible regions. Light weight, rapid response, helicopter equipment has been constructed and successfully tested, but has not yet been used in the field.

Uranium prospecting should be a major application of sensitive gamma ray detectors. Airborne equipment would permit a rapid survey of relatively unexplored areas.

Limitations. The gamma ray survey yields considerable information about sub-surface conditions, and it is very successful in the location and projection of faults. It points out structural formations which are favorable for the accumulation of oil, but it is not a direct method for finding oil. Its use should be correlated with geological studies whenever possible.

The giant ionization chamber used in gamma ray surveys should be welcomed as an important geophysical tool, and an aid in the exploration for oil. —**The End**

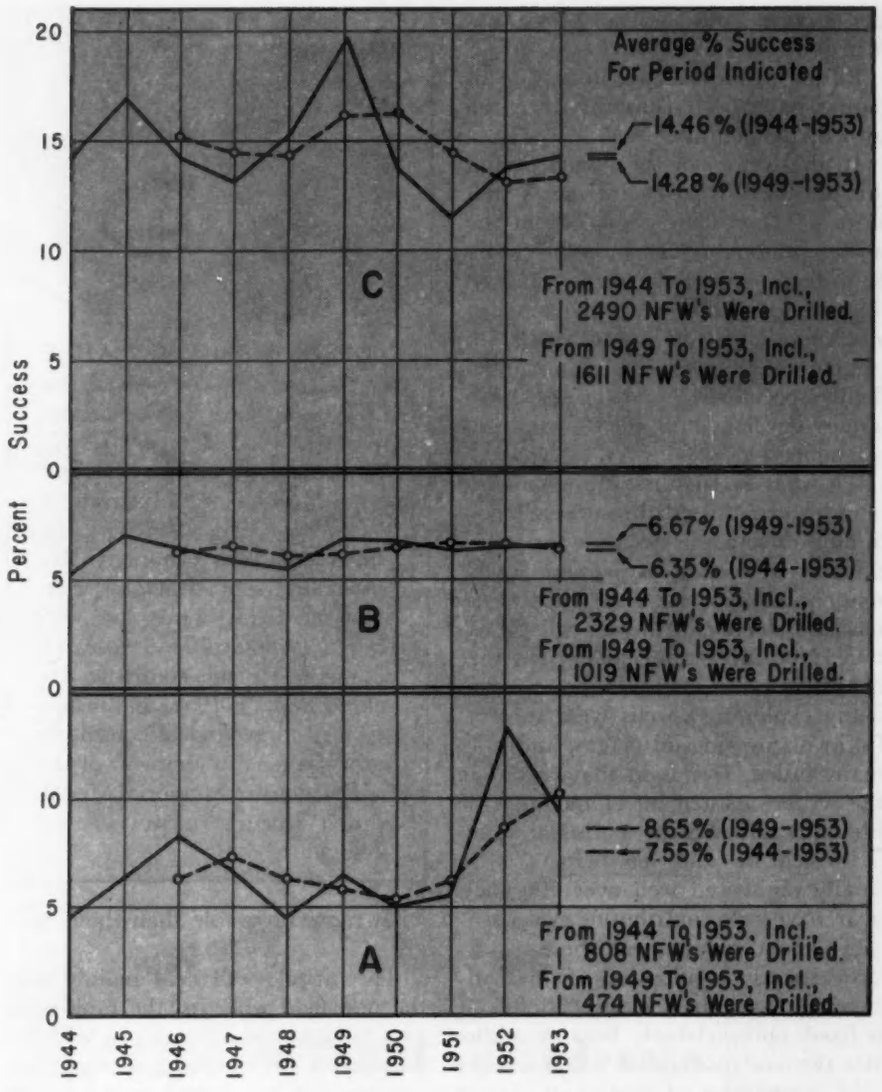


FIGURE 1—Percent success figures for new field wildcats drilled in three different states (here called A, B and C) in the years 1944 to 1953, inclusive. The solid line represents changes in the percentage of success from year to year. The dashed line shows the changes in the three-year averages, the value being recorded at the *end* of each three-year bracket. Note that by using these sliding three-year averages, the range in percentages is less than those for single years. This figure not only illustrates the fluctuations in success in new field wildcatting from year to year, but also proves that the percentage of success, or success-to-failure ratio, is highest in Area C and lowest in Area B.

Statistics Play Vital Role in Exploration

Results achieved through the use of the statistical factor are impressive.

By FREDERIC H. LAHEE
Consulting Geologist, Dallas

THE APPLICATION OF STATISTICS based on accurate research can be of considerable value in exploratory drilling.

Furthermore, statistics can be used in various ways, such as:

1. To measure past percentages in finding new production, either in all of the United States, or in selected areas.
2. Estimate future exploratory possibilities.
3. Help investors calculate the risks they must take in different districts and provinces.
4. Enable banks to better estimate the risks involved in making oil loans.
5. Furnish operators with an intelligent basis for checking their exploratory results by comparing their figures with the industry's averages.

These are some of the applications. There are many others. In fact, the statistical factor has become another weapon in the arsenal of oil and gas exploration. It is designed to improve the success ratio in finding oil and

gas reserves. And statistics prove that it is doing so successfully!

Efforts to improve oil finding techniques have been constant since the turn of the century.

In the history of the search for oil this has applied to geological as well as to geophysical methods—from the surface mapping and the correlating of drillers' logs in the teens, through the introduction of micropaleontology and geophysics and electrical well-logging in the twenties, to the more highly specialized, more precise techniques developed in the thirties and subsequently.

To what extent these developments may have increased the success in oil finding during the twenties and early thirties, we cannot say. There is absolutely nothing in the published records which can answer this question. Not until after 1935 was any consistent effort made to find out how many exploratory wells were successful in discovering oil or gas, and how many failed. It was in that year that the writer, assisted by 11 members of his staff, initiated the statistical study to which he and his helpers, who finally numbered well over 100 each year, have been contributing ever since.

The first requirement for any statistical study is adoption of, and adherence to, a fixed classification and a fixed nomenclature, because statistics demand listings of like numbers and comparison of groups of clearly defined data. To attain this objective many hours were spent in drawing up a classification which could be applicable everywhere, and which, now, is generally accepted and followed by a large percentage in the industry.

Briefly, we defined five types of exploratory hole. One we called "new-field wildcats," because, when successful, these discovered entirely new fields, far removed from any previously known oil or gas producing areas. The other four included long extensions of pools already found, or new pools (reservoirs) on structures already producing. In our classification use is not necessarily made of the terminologies of state regulatory bodies, nor of individual companies. In the former case, there is too often a tendency to seek high allowables by claiming that newly discovered pools or extension wells are discoveries of new fields; and in the latter case, there is sometimes a tendency to classify the exploratory drilling so that the reported results will look somewhat more favorable than they really are.

About the Author

DR. FREDERIC H. LAHEE of Dallas, Texas, received his A.B., A.M. and Ph.D. degrees from Harvard University. He taught geology at Harvard and at the Massachusetts Institute of Technology until 1918 when he joined Sun Oil Company. He served as chief geologist from 1920 to 1947, when he was named geological and research counselor for the company. He retired Sept. 1, 1956, and is now engaged in geological consulting work. Lahee is a recipient of the Sidney Powers Memorial Medal, highest honor in petroleum geology.

This article will deal mainly with the new-field wildcats, the rank wildcats, because these furnish us with the measure of our discovery success. Conclusions will be limited to the figures from 1944 to 1955, inclusive, since, before 1944, our data were not wholly complete.

What do we learn from these data on wildcat drilling in this 12-year period? Here are some of the salient facts:

In this 12-year period 58,031 new-field wildcats were drilled in the United States.

Of these, 6927 (or 11.94 percent) were completed as producers, and 51,-104 were dry.

When located on technical advice, either geological or geophysical, or both, successful wildcat completions were obtained nearly three times (actually 2.81 times) as often as when the wildcats were located on some non-technical basis.

If we break down the figures for technically located wells, we find that, in the 12-year period,

- 3126 holes located solely on geological advice were producers, and 29,676 were dry; that is, 9.53 percent of the 32,802 holes were successful.
- 1619 holes located solely on geophysical advice were producers, and 8728 were dry; or 15.64 percent of these 10,347 new-field wildcats were successful.
- 1106 holes located on both geological and geophysical advice were producers, and 5938 were dry: or 15.70 percent of these 7044 holes were successful.

During the 10-year period, from 1946 to 1955, inclusive, there were 14,559 new-field wildcats drilled at locations made either by seismograph or by seismograph in combination with other methods, and of these, 2574, or 17.67 percent were producers.

In considering these statements it should be remembered that selection of the particular site where the well is drilled is what is meant by "the basis of location." This selection is most commonly made on detailed geological or seismic mapping. Not included are preliminary reconnaissance methods which led to the blocking or checkerboarding of acreage over wide areas unless these were the only methods applied in the choosing of the well location.

There is also another point which should be understood. This matter of recording failures and successes in exploratory drilling is not for the purpose of measuring the ability of geologists and geophysicists in the application of their sciences. Not infrequently a structure, which has been well-mapped and which supposedly is underlain by a stratigraphic sequence which should contain oil or gas, is drilled and found to be dry. The mapping of the structure was good. The technical advice was good. And the site for the well was properly chosen. The only thing wrong was that oil was not present in the reservoir rock, a fact which could be demonstrated only by actual drilling of the hole. It is for reasons like this that we claim that the recorded ratios between successes and failures in wildcat drilling are truly measures of the hazards inherent in exploratory drilling.

In the 10-year period from 1944 to 1953, inclusive, we contrasted the results obtained by major oil companies, on the one hand, and by minor oil companies and independents, on the other hand. We defined these classes of operators as follows:

A. An 'independent' is an individual, syndicate, family, or company, without regard to financial size, which

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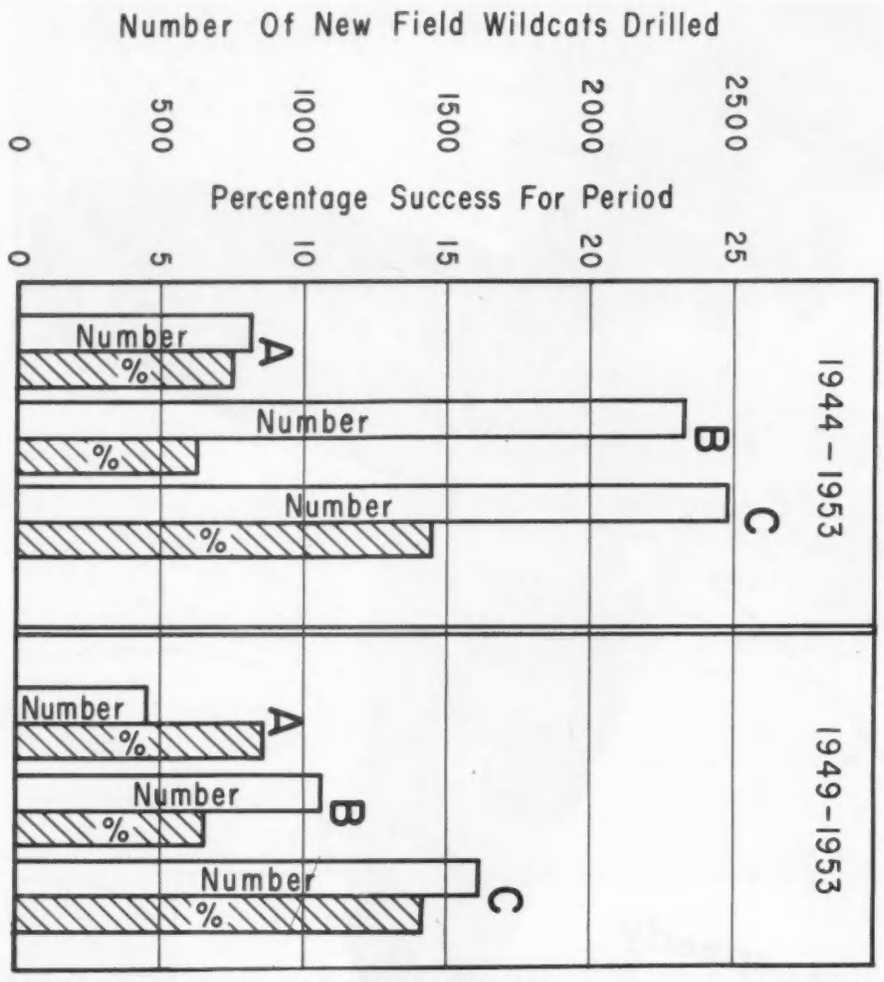

FIGURE 2—The number of new field wildcats drilled, and the percentage success in this drilling are contrasted in States A, B and C for the whole ten year period under consideration and for the last five years of this period.

does not have stock available to the public through sale on any exchange, or curb, or 'over the counter.'

B. Both 'majors' and 'minors' are companies or corporations which have stock held by the public and offered for sale or purchase on some stock exchange, or curb exchange, or 'over the counter.'

As criteria for discriminating between 'majors' and 'minors,' we have the following:

1. A major company should be integrated with respect to at least three of the four main activities of the petroleum industry, namely, production, transportation, refining, and retail marketing. In any case, one of these activities *must* be production.

2. A major company should operate (lease, drill, and produce) in two or more states, or in two or more major divisions of a state (such as the divisions of California, Louisiana, and Texas).

3. A major company should have its current assets equal to, or greater than, a certain arbitrarily designated level. For purposes of the Committee on Statistics of Exploratory Drilling, of the American Association of Petroleum Geologists, this level was recently set at 30 million dollars. (For further details on this classification of operators, see pp. 989 and 990, in Vol. 36 of the Bulletin of the A.A.P.G.)

During the 10 years from 1944 to 1953, inclusive, 13,634 new-field wildcats were drilled by, or largely financed by, major companies, and 28,581, by minors and independents. That is, only 32.3 percent of all these wildcats were drilled or financed by majors. The results of this drilling showed that the majors were 15.23 percent successful as contrasted with only 9.75 percent success for the minors and independents. This was no doubt because many of the minors and independents located their wells without technical advice. All through our studies the fact is repeatedly clear that application of scientific methods in selecting sites for drilling wildcats yields a higher degree of success in discovery than failure to use such methods.

It has been our custom in assembling these statistics to define a "successful well" as one which was completed as a producer *in the year of discovery*. A new-field wildcat, so completed, is rated as the discovery well of a new field. Some of these "discovery wells," after a few months or a year or two, turn out to be noncommercial and they are therefore abandoned. Other wells, at first thought to be discovery wells of new fields, are, by subsequent drilling, found to be long extensions of fields already partly developed. So it happens that, as the years go by and field-development wells are drilled, the ratio of success to failure changes somewhat from the value reported at the close of the year of discovery.

Because of its great significance for the oil and gas industries, attention is called to its discussion in A.A.P.G. Bulletin, Volume 40, Number 7, July, 1956, pages 1678-81. In the article entitled: "Degrees of Success in Wildcat Drilling," the final scoring for new-field wildcat drilling, after six years of development history, is shown to be only one true success out of every 10 such wells drilled.

And it is further pointed out that:

- Only one wildcat in 42 drilled discovered a field with a total ultimate recovery of as much as 1 million barrels;
- Only one wildcat in 158 drilled discovered a field with a total ultimate recovery of 10 million barrels, or more;
- Only one wildcat in 427 drilled discovered a field with a total ultimate recovery of 25 million barrels, or more; and
- Only one wildcat in 706 drilled discovered a field with a total ultimate recovery of 50 million barrels, or more.

All the figures quoted up to this point have referred to the entire United States, except those in the last paragraph, which apply to the 17 states in which over 95 percent of the new-field wildcat drilling was accomplished in the period indicated.

Attention now is called to several more limited uses to which these statistics can be put, but uses which are highly significant for individual companies, for banks in appraising the risks for loans, for investors contemplating the expenditure of money for

Continued on page 138

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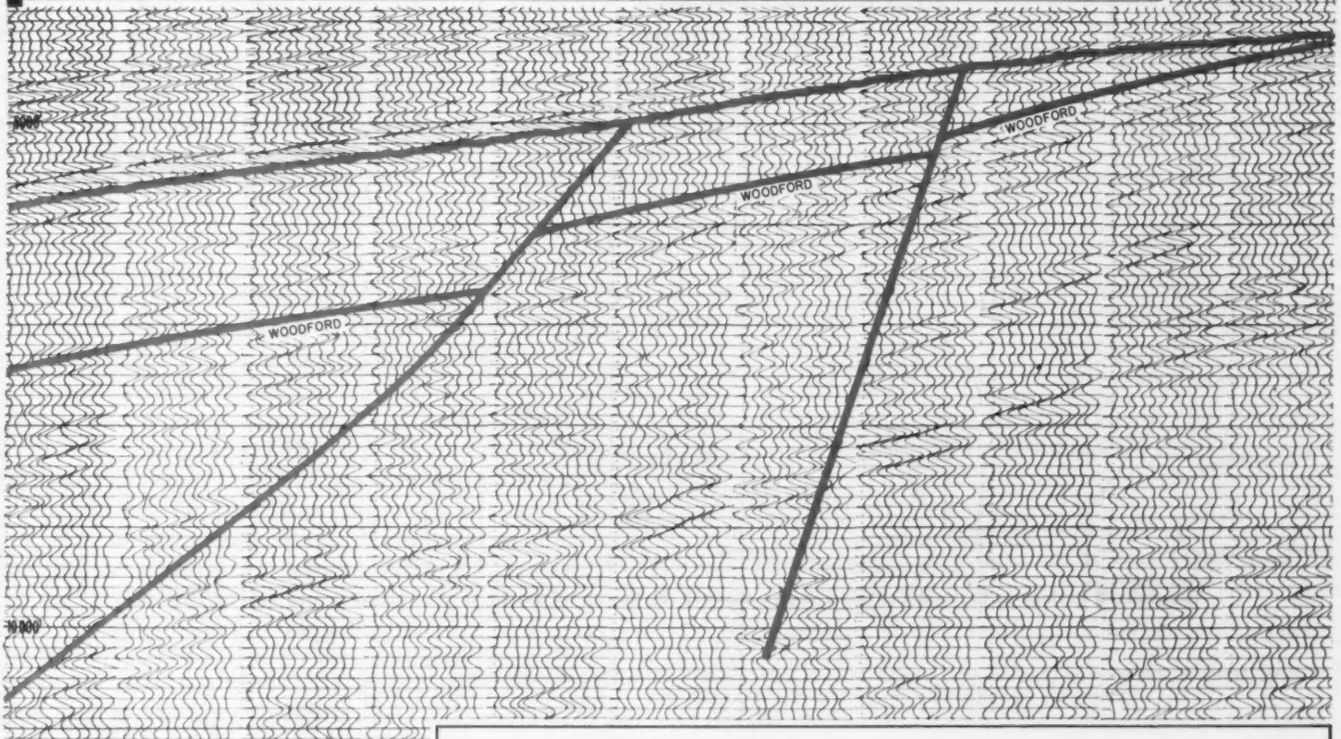

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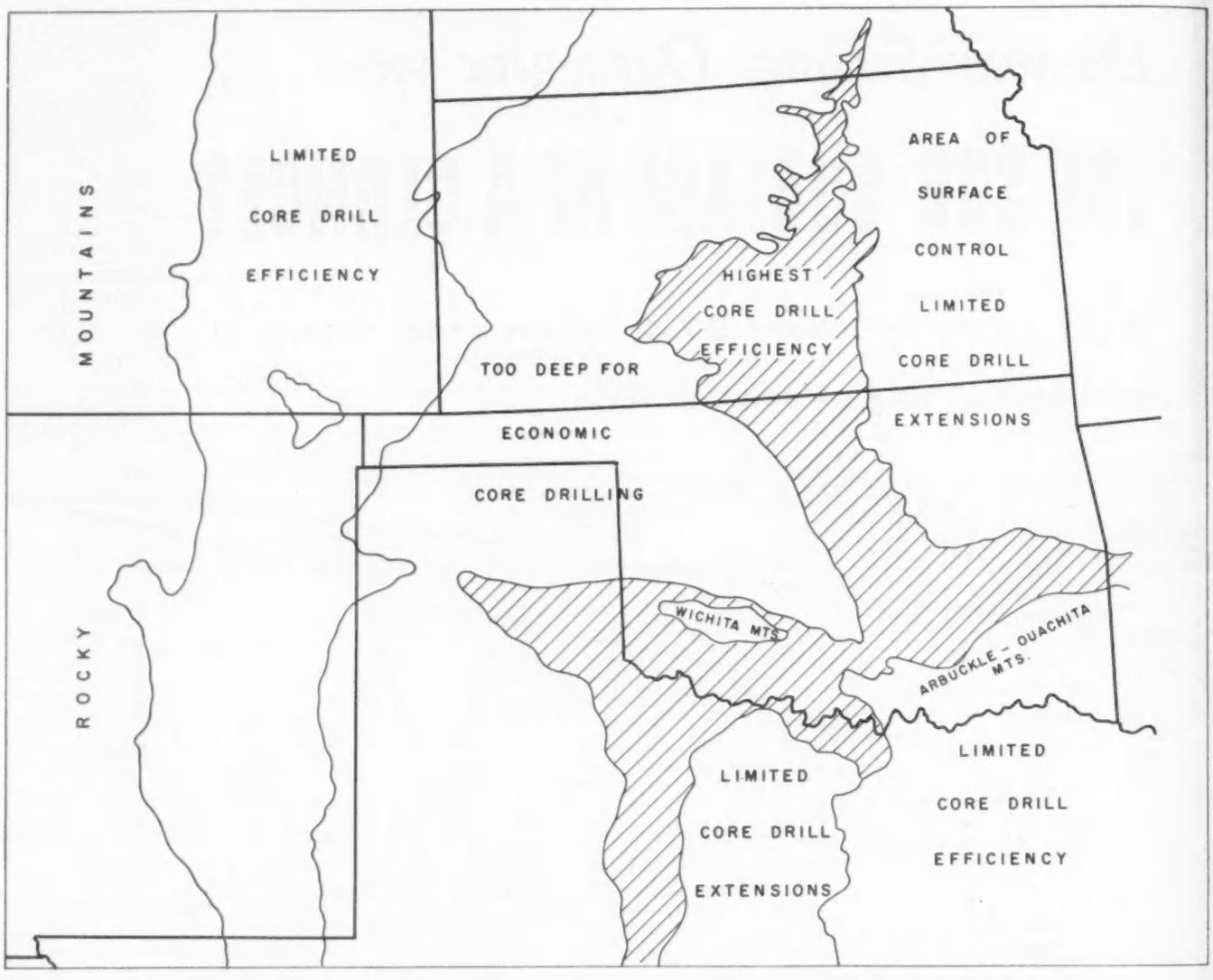
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Generalized geology in the Mid-Continent region showing the horizontal extent of most efficient core hole exploration.

Modernized Core Drilling for Structure

Here's a new exploratory method which is valuable when:

- **The existence of a subsurface anomaly is suspected.**
- **There is a need to complete or extend an old surface map.**
- **An operator desires to confirm a gravity anomaly or seismic suspicion.**
- **It is desired to explore an area where extreme seismic difficulties have made older core drilling methods unsatisfactory.**

By R. W. BIGGART
Geo-Log Structures, Inc.
Tulsa

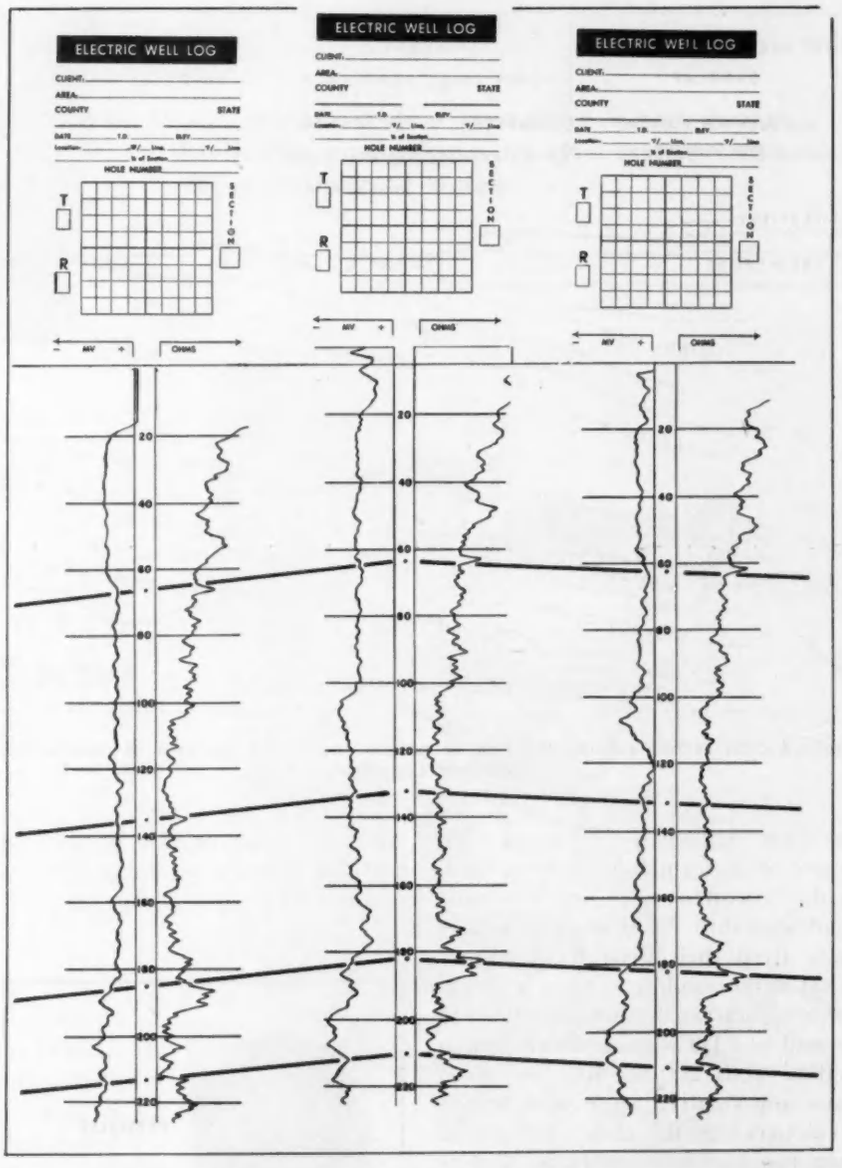
A NEW LOOK to an old exploration technique is now being applied with success in the Mid-Continent area.

The method consists of electric logging shallow core holes with a device similar to that used in drilling deep wells. The purpose is to determine depth, thickness and elevation of formations that give indication of deep oil pools.

The instrument is adaptable as either an electric log or as a gamma ray log. The new logs make all formations drilled usable to the geologist.

Equipment used in this modern core drill exploration for deep seated structures consists of a small mobile drilling unit capable of drilling holes of 3-, 4-, 6- and 8-inch diameters to depths of between 1000 to 1400 feet. These rotary rigs are readily available as adaptations of seismic drills with their water tank truck tenders.

The logging units are light weight equipment mounted on trailers, in pickup trucks, small panel trucks, or on skids to be hauled by any type of conveyance. They can be powered with batteries, or small gasoline engine driven generators. Small diameter cable spools with from a few hundred to 2000 feet of woven wire cable are either hand cranked out of the hole or motor drawn in the more precise instruments. The recording devices are as varied as modern electronics will allow. Some are Wheatstone bridge circuits, while others are complicated galvanometer actuated shadow wires projected onto a photographic film. Some have ink filled stylus pens tracing resistivity and potential curves on recording charts while others are photographed simultaneously on sensitive film recording the minute lithologic variations of the limestones, shales, and sandstones penetrated by the drilled holes. The detail and sensitivity of these logs when operated by experts provides utmost accuracy in determining structural differences, and isopachus changes. Some instruments are adapted to survey the radioactive character of the rocks penetrated and these logging units are finding increasing usage in shallow cased holes and in the uranium areas of the mountain states. Some seismic crews and oil companies are running gamma ray logs in all of their seismograph holes in order to evaluate the radioactive content of near-surface rocks.

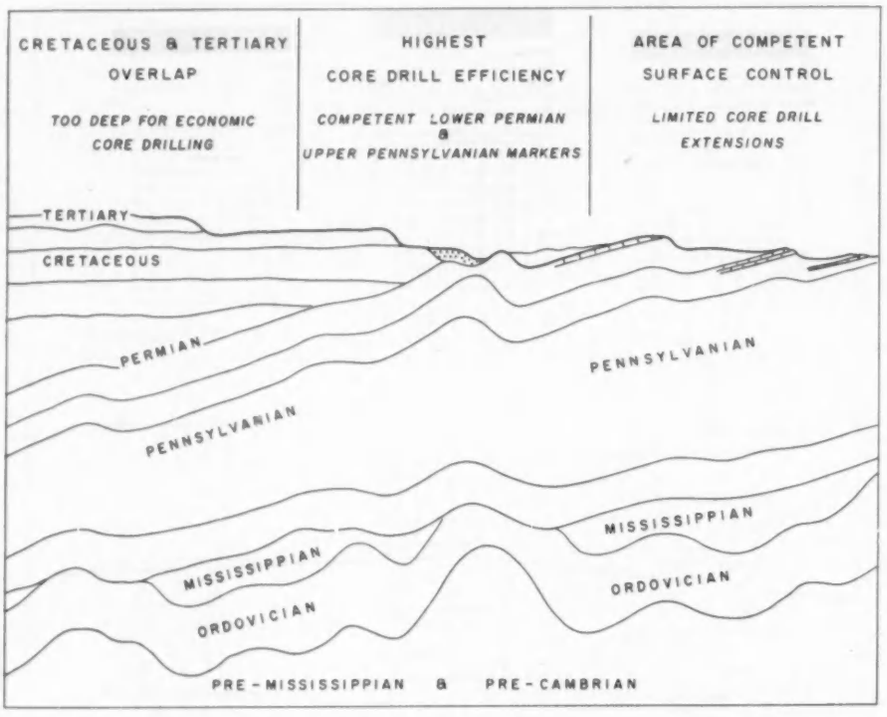


Correlation character of electric logs run in shallow core holes. The location of these holes is not identified as to state or geologic age purposely.

In addition to the foregoing equipment a complete crew consists of a surveying crew for horizontal and vertical control. Structure mapping above all else must rest on accurate elevation differences. The men who are experienced as drillers, electric-loggers, and surveyors, together with a coordinator, such as a geologist or geological engineer, are of course essential.

Leasing or trespass permission is frequently desirable, though not always necessary. The surveyor secures a written permit from the land owner and stakes out the first two or three holes in chosen field corners, having an eye toward easy truck manoeuvering and minimum crop damage. The location and arrangements for drill water are also important items for the first day's work. The drilling of the hole then begins and the surveyor runs the elevation from a nearby bench mark recording the hole location from the nearest section line.

Some preliminary thought and investigation has been made by the geologist as to type of rock to be encountered with an estimated depth in mind. Several considerations should have entered into that thinking. Can we expect competent consistent structural markers at reasonable depths? Are they hard and therefore expensive to drill through? Can they be tied into deep hole electric logs in the vicinity?



Idealized cross section showing the type of geology that limits the area of most efficient core hole exploration.

Do these shallow rocks have a high degree of conformability to deep beds, or do disconformity and diastemic conditions shift the shallow structures away from their deep focal points? What is the shallowest (and least expensive) marker that we can afford to depend on? Do isopach differences in shallow beds 200 to 400 feet apart have any significance over known structures in the area? The driller then has had instructions as to how deep to drill the first one or two holes and proceeds to that depth.

Many "know how" methods of cleaning small diameter holes have been developed and can be discovered only by long experience. The electric log recording tool that is run down the hole must be heavy enough to sink in the residue mud and small enough to travel between the walls of the hole with their built up mud cake to the depth drilled. Here is one spot where trouble can and does develop. Assuming that the probe device reaches the total depth and the operator has checked measurements and made all electrical adjustments while running into the hole; then the film is readied, final mechanical adjustments made and the logging commenced from the bottom out to the surface.

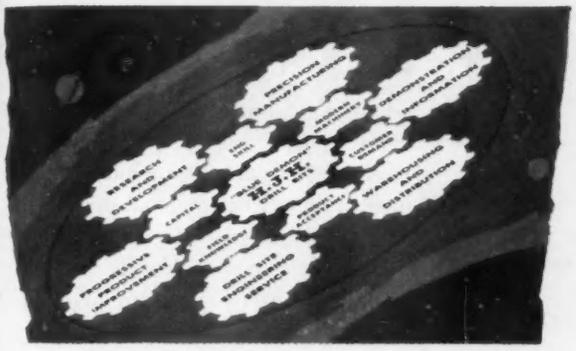
Success is achieved when the probe appears at the ground level and the measuring device has returned to zero. Now the chart or film is developed and the operator seeks the first clues as to stratigraphic sequence, curve centering on the depth and electric value grid lines, with an appraisal of "character" that will probably persist to several other holes. One log will seldom establish these facts unless the operator is thoroughly familiar with the area. The drilled hole has served its purpose (unless the geologist decides that it should be taken deeper) and is then plugged. Of course, samples could have been caught and a lithologic log made, or actual cores could have been cut from rock examination and identification had the operator so desired.

After the second and third holes are cut and logged, the correlation value of certain rock beds become apparent and their character is judged reliable allowing the map to be begun. Depths of the same marker bed are determined, the elevations applied, and a datum figure emerges revealing the shallow structural difference between the holes. From this point on the geologist directs the next several holes to be drilled at locations that will complete what he hopes will be a structural anomaly such as a closure or flattening on a nose, or a contour swing in some critical direction that is known to be significant in a given province. Actual physical structure is then, here being discovered and mapped without fear of velocity gradients, or changes, with a minimum of human element error, at depths below weathering slumpage of surface outcrops and with the certainty that any slight folding must be caused by deeper influences of much greater magnitude. The anomaly has now been confined to a very local area. The exact location, of course, may then depend upon application of intense sub-surface study; coordination of other geophysical information and finally the drilling of the production hole to the producing horizon.

The application of this kind of oil search in extending surface control out into river valleys, where outcrops could not be found requires only a few holes to tie up the missing side. Again much of the outcrop area of the Mid-Continent region is covered by high plains back of the actual outcrops and the gentle topography does not again expose surface rocks for many miles although it is known that those rocks exist at shallow depths. Frequently slumping of overhanging ledges on a large scale has caused the mapping of false dips by surface men

About the Author

R. W. BIGGART has been engaged in geological work for 30 years, working primarily in the Mid-Continent area for Empire Gas and Fuel Company, White Eagle Oil and Refining Company, Deep Rock Oil Corporation and other oil producers. Specializing in core drilling, he has had extensive experience in surface field work in Oklahoma, Texas, Missouri and Colorado. He is president of Geo-Log Structures, Inc., of Tulsa, which engages in structural mapping by core hole logged methods coordinated with general geology.



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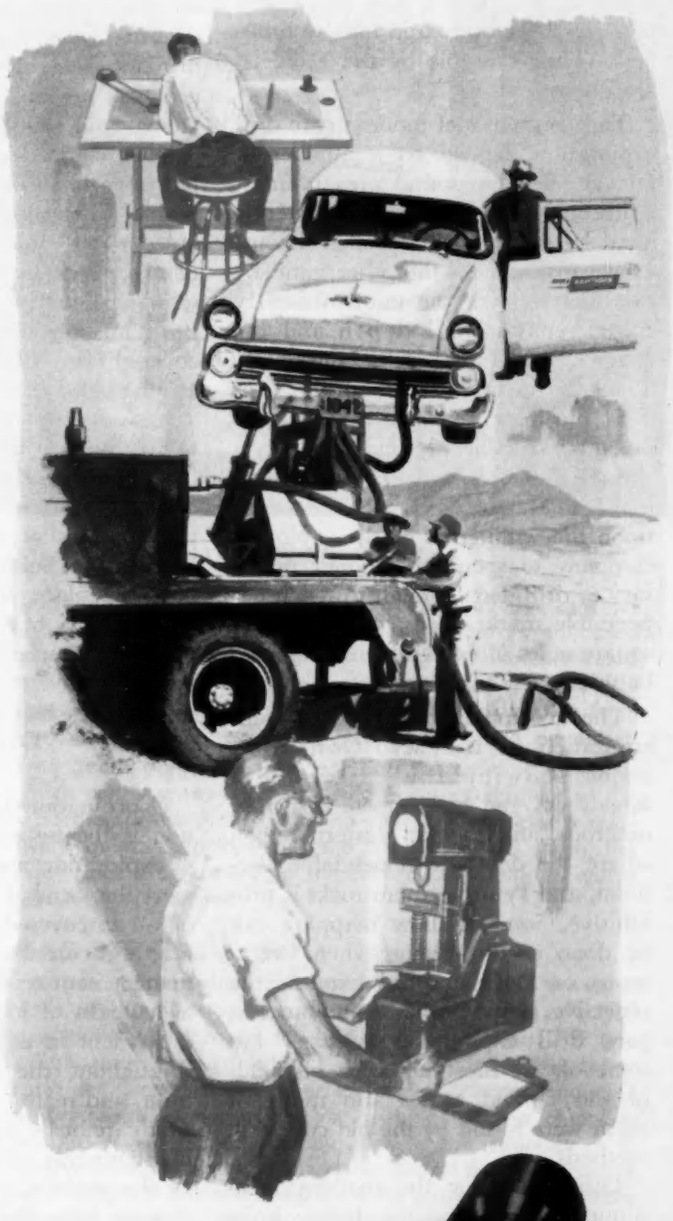

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when they did not have opportunity to check intervals with over-or-underlying formations, as well as the ever present chance of miscorrelation along discontinuous ledges or between non-character exposures such as monotonously alike sandstones. Much of the Permian outcrop area of Kansas, Oklahoma, and Texas is covered by soft shales that do not yield competent outcrops, but which can be logged by electric methods, and minute lithologic changes usable by the geologist are discovered.

The economics of modern core drill exploration depend on a number of factors. The horizontal area of most efficient use is limited on the one hand by the availability of good outcrop beds, and on the other hand by two factors, viz., the economically considered vertical depth and the competency of the rocks penetrated. There is no use in core drilling for map purposes an area that can be much more cheaply mapped by a surface geologist and one instrument man. The other extreme depends upon the willingness of the exploring company to spend the money necessary to drill deep enough to reach dependable marker beds. Thousands of square miles of explorable territory lie between these two extremes.

The accompanying map is a generalization of the Mid-Continent region showing the eastern area largely covered by competent surface outcrops, and the far western region where the depth to dependable Permian, and Pennsylvanian rocks is prohibitive. Some shallow mapping can be done in this region when Cretaceous or Permian production is the objective. Between these boundaries in core drill exploration territory are some of the most lucrative oil fields of the United States and many of them were found by the old core drill methods.

Other uses for the modern technique of electric logging shallow holes are being developed continuously. The recent exploration fever for radioactive minerals has produced a large demand for gamma ray logging of shallow drill holes, and the recording of gamma character in seismic holes is an efficient and inexpensive method of exploring large territories. Some recent use has been found for drills of shallow depth capacity in water flood projects where production can be reached by the drill, and the logging of these 600 to 1400-foot holes is giving the geologist the first scientific knowledge of the stratigraphy and true structure of many of the oldest and quite famous pools of the oil industry's colorful past.

With the continuing drouth in the western regions and in truth the lowering of the fresh water tables all over the continent, water-starved communities and agriculturists are turning to scientific search for more and more drinking and irrigation water. The geologist has only to apply some well known and sound principals of basic geology coupled with the tools of exploration to assure a great increase in usable water supplies. Shallow drilled holes with electric logs to record depths, thicknesses of sand beds and structural control are indispensible for this kind of work. When once discovered the sand reservoirs can be outlined and the volumes tested much as oil wells are tested.

Finally let it be said that core drilling is by no means the answer to declining discovery rates. All of the proven tools of exploration must be put into use. Seismograph must always have its place in hunting for large and deeply buried structural complexes, but surface and core hole mapping also have their place in discovering that ancient positive features are detectable—"Old structures never die."

Coordination of all such information is the responsibility and interest of exploration managers. Let them review the number of pools and barrels of oil discovered in the past by surface and core drill methods alone. Let management understand the value to a geologist of knowing the history of movement in any structural anomaly throughout the entire geologic column, and realize that if deep exploration cannot be supported by evidence of structural rejuvenation expressed to the surface, serious doubt can be thrown into the existance of that anomaly. Let gravitimeter anomalies be proven as positive or negative entities with accurate structural control gained from electric logs in shallow holes. Thus management will help to revive one of the most useful and economic tools ever devised for the much overworked geologist, who at best, is sparring with the most clever and tricky guardian of our natural resources—Mother Nature.

—The End

Statistics in Exploration

Continued from Page 132

oil or gas properties, and in many other ways.

First, any company which is active in exploratory drilling can compare its results, at the end of each year, with the industry's results for that year, or in brackets of two or more years with the industry's results in the same periods; but to do this properly and to secure a reliable comparison, such a company *must* classify its exploratory wells exactly in accordance with the industry's classification of exploratory wells. To compare unlike groups of figures is absolutely valueless. In view of the real significance of this statistical checking, for any company, it is surprising to find how few apply it in their annual reports to management.

Second, a company or an investor, wishing to select the more promising areas in which to spend money for exploration, or for the purchase of oil or gas properties, can ascertain the results of the petroleum industry's exploratory effort in special districts, states, or regions. This should be done by totalling the figures for several years, and comparisons can be made between periods just elapsed and equal periods in the more distant past. For instance, the data may be studied for five-year brackets, or for three-year brackets, and so on. Curves, in such cases, are best based on annually overlapping brackets of two, three, four or five years each. (See Figures 1 and 2.) In considering this second use of the statistical factor, we wish to make clear that we are proposing this procedure only as a sequel to regional geological recommendations. The first question to be answered, and this must be answered affirmatively, is this: Is the prospective area situated within a geological province that includes relatively favorable regional structure and regional stratigraphy? If so, then the statistical factor derived from past exploratory activities may be applied.

A third and more restricted use of the statistical factor is in checking the relative performance of the reservoirs in different geological formations. From a study of this kind, inferences may be drawn as to the economic advisability of deepening certain wells.

ACKNOWLEDGMENT

The author thanks the Society of Exploration Geophysicists for permission to publish this paper based on a presentation at the annual meeting of the SEG, at New Orleans, October 29, 1956.

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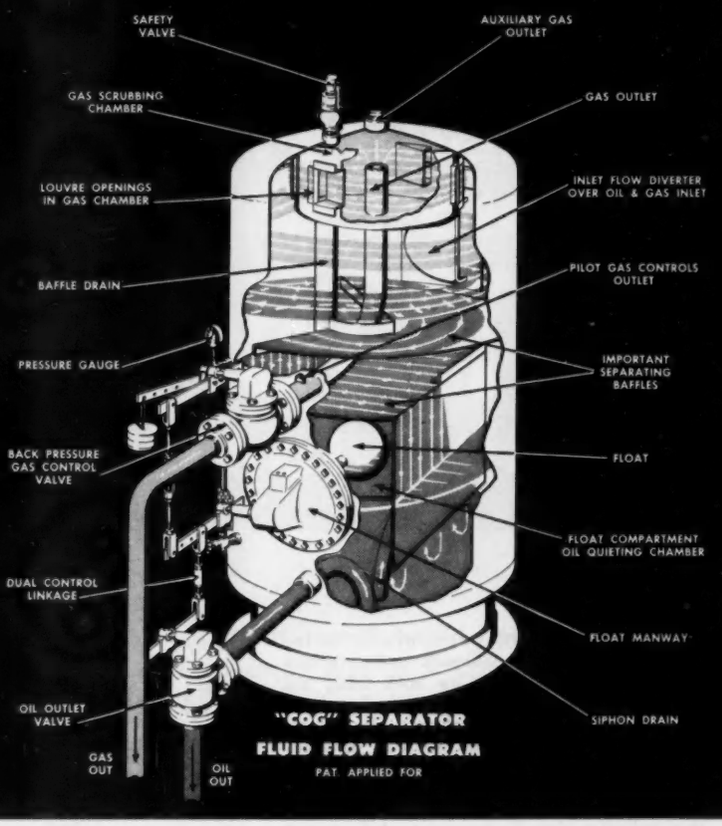

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The oil travels circumferentially about the separator in a relatively thin film, thereby presenting a larger surface from which the entrained gas is "broken out." This larger oil surface contributes toward greater oil capacities. The greater the fluid volume at the inlet, the greater the initial fluid velocity and the longer the scrubbing travel against the side wall of the separator; that is, the higher the jet velocity at the inlet, the farther the fluid will travel around the side wall of the separator before coming in contact with the first horizontal baffle plate.

Here the liquid continues to be spread in a thin film forcing more gas to be liberated, then the liquid cascades from the first horizontal baffle plate down to the top of the quieting chamber to continue its travel in a thin film. The liquid flows over the quieting chamber roof and side wall. Note that oil is collected outside of the quieting chamber and has further opportunity to liberate entrained gas. The oil in this chamber containing the least entrained gas is drawn off the bottom and flows under the baffle into the final quieting chamber. The oil is withdrawn from the bottom of the separator through a siphon oil outlet.

Free gas is prevented from entering the quieting chamber which assists greatly in producing early equilibrium at the separator pressure. The quieting chamber provides a relatively quiet surface within the separator on which the float rides thus conveying smooth action to the oil valve actuating equipment.

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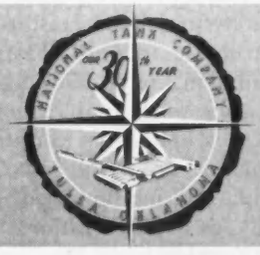

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Florida's oil prospects, particularly in the southern part of the peninsula and extension areas in offshore waters on both sides, are good. Exploration to date has been hampered by a multitude of tough problems. Geophysical exploration by all methods has had generally negative results. But if exploratory wells can be drilled for less cost in the future, results should improve. Limited subsurface information indicates that Cretaceous and lowermost Tertiary limestones should be productive along trends spanning the southern parts of the peninsula, roughly parallel to the south flank of the Ocala Uplift.

South Florida Oil Prospects Are Good

Exploration is difficult but very little prospective acreage has been condemned.

By H. T. BRUNDAGE
WORLD OIL Staff

INTEREST ON the part of more than 25 oil companies currently holding acreage in Florida continues, particularly in the Sunniland trend in the southern part of the Peninsula. This area, consisting of a band about 30 miles wide by 200 miles long, extends through Sarasota, Charlotte, Lee, Hendry, Collier, Monroe, Broward and Dade counties and represents the apparent fairway of Sunniland limestone prospects.

Exploration in Florida has been hampered by a number of drawbacks. Rock exposures generally indicate a featureless surface. Where they do show localized structural features, they do not generally serve as a reliable indicator of structural conditions affecting possible oil accumulations in prospective subsurface formations. It has been hard to achieve good seismic data because of difficult surface and subsurface conditions. Low structural relief of deep producing structures found thus far puts apparent limitations on the usefulness of seismic data where good records can be acquired. The irregular nature of the crest of the pay section at Sunniland field emphasizes that stratigraphy may be at least as important as structure in south Florida oil accumulation, again limiting the value of seismic work as an exploration tool. There is too little variation in the magnetic properties of the thick Florida marine limestone section to justify great expectations from magnetic exploration. The only way in which Florida oil is going to be found in the large quantities that some oil

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SEISMIC GRAVITY MAGNETIC SURVEYS

men feel may be there is for more wells, particularly deep tests, to be drilled.

The previous discussion serves to explain why Florida has been neglected in favor of more easily workable U. S. oil provinces. An additional drawback, perhaps the most important, is that drilling in Florida has generally been very difficult and expensive. Nevertheless, the favorable Sunniland trend, which probably extends northwestward from Sarasota County into the Gulf of Mexico and southeastward from Dade County (Miami) toward the Bahamas, has been fairly well defined by sparse drilling done thus far. Since the discovery of Sunniland field in 1943, only 39 wells have been drilled within the limits of the indicated fairway, and all except one of them had oil shows in the Sunniland limestone. Of these tests, 16 were oil producers, with initial production of from 97 to 527 barrels daily.

The outstanding drawback to Florida exploration is perhaps that, so far, the best known prospects are deep, and attempts to extend the productive horizon into shallower areas have been unsuccessful because the Sunniland formation, the only one found productive in the state so far, has either thinned too much or has disappeared entirely at locations on the flanks of the Ocala Uplift. This regional feature, very important to the geology of Florida, is located in the central part of the Peninsula and is a buried highland, not an anticline. The prospective Cretaceous beds are shallower farther up on the Ocala Highland but attempts to establish production there have been unsuccessful, largely because of thinning or disappearance of key horizons.

In the Panhandle of northwestern Florida, a recent attempt to find Rodessa sand correlative with that producing at Citronelle field and other localities in bordering Alabama has resulted in a strong suggestion of a South Florida type (limestone) facies in the Cretaceous, unlike the Citronelle Rodessa sand development. But this interpretation may also enhance offshore prospects in the Florida Gulf, as nothing is known at present to negate the possible extension of the Sunniland trend at a theoretical optimum distance off the southwest flank of the buried Ocala Highland. Hence, a productive band or arc may be envisioned, extending counter-clockwise from the western end of the Florida Panhandle to Sarasota County, thence traversing the Peninsula in a southeasterly direction, and continuing into the Atlantic Ocean toward the Bahamas.

Gulf Oil Corporation and Standard Oil Company of California continue their interest in the Glen Rose (Sunniland) possibilities of the shallow coral atoll areas of the Bahamas, and are hopeful of locating a drillable structure there through seismic and other geophysical work. Along the West Coast of Florida, The California Company has been involved in recent waterborne seismic operations from Apalachicola on the Panhandle coast to Naples in Collier County, the same county in which Sunniland field is located.

Florida's oil production began in 1943 with the completion of the Humble Oil & Refining Company Gulf Coast Realties Corporation 1 about 48 miles southeast of Fort Myers and 80 miles northwest of Miami. Completion was from open hole at about 11,500 feet. Initial production was 97 barrels of oil and 427 barrels of salt water in 24 hours.

To date, 14 wells have produced oil at Sunniland. Production has declined very gradually, from a peak of 54,000 barrels per month during mid-1951 to 48,000 barrels in March, 1954, to 42,500 barrels in March 1956. An excellent water drive is apparent. Gas/oil ratios are very low, in the order of 100 cubic feet per barrel or less. But reservoir pressures are sufficient to lift the oil more than 7000 feet, where all the wells are pumped at an average rate of 120 barrels per day at depths of 3000 to 4000 feet. Thus lifting costs are low, despite the fact that these deep wells have to be pumped. There is fairly good permeability in the pay section, usually in the order of 300 millidarcys.

Average porosity is about 18 percent. Hence, Sunniland field is being successfully produced on 160-acre spacing. The oil horizon, the Sunniland limestone of the upper Trinity or middle Albian section of the Cretaceous has been determined from fossil evidence to be equivalent, or almost so, to the Walnut member of the Glen Rose limestone, exposed so prominently near Austin, Texas. In addition, fossil evidence correlates the Sunniland formation with El Abra limestone, prolifically productive in the Golden Lane fields of southeastern Mexico at depths varying from 3000 to 7000 feet.

Total cumulative production to date from Sunniland field is about 5 million barrels. Approximately the same amount may be expected to be recovered before it is depleted. The pay varies in thickness from 5 to 20 feet. There are probably two separate pays. Apparent irregularity of the pay horizon at the crest of the structure indicates a disconformity and affects pay thicknesses in the eastern and western segments of the field.

It is evident from subsurface maps of the Sunniland field that there is about 50 feet of oil column. However, going down structure, the oil zone at the crest grades into a mixed oil-salt water zone, which in turn grades into 100 percent salt water, of very high salinity. Of course, very few oil fields have a clearly defined oil-water contact that can be expressed as an exact datum, consistent in all parts of the field. But the gradation zone is highly pronounced at Sunniland, such that, in general, flank wells have produced profitably for many years, despite the fact that some have made large amounts of salt water from the outset. The oil and water are not emulsified. It is not clear how much closure exists at Sunniland. There is a pronounced, though localized, structural trough off the north flank of the field, about 150 feet below the crest of the structure at its deepest. However, a relatively high dry hole east of the field indicates that there is considerably less than 150 feet of actual closure. The most likely interpretation indicates there is about 50 feet of

closure at Sunniland and that the structure is almost full of oil.

The Sunniland field is 3½ miles long parallel to its structural axis (west northwest—east southeast) and has a maximum width of one and one-half miles. The crest of the structure is relatively broad and flat. Reversal along the northeast flank is at the rate of about 150 feet to the mile, somewhat steeper than the more nearly regional (southwest) dip on the downdip side of the structure. There are about 2800 productive acres in the field.

Crude oil found in the Sunniland formation so far has been of 26.4 degrees API gravity or heavier. On fractional distillation, one sample yielded 20 percent gasoline, 35 percent gas oil, and 45 percent residual oil, high in asphalt and low in sulfur and salt contents.

Forty Mile Bend Field. Florida's second oil field was brought in early in 1954 with the completion of Commonwealth Oil Company et al number one Wisehart-State, in Dade County. Completion was from Sunniland dolomite at 11,323 to 11,328 feet for 175 barrels of 21-gravity oil and 117 barrels of salt water per day after acidizing. The field is located 36 miles west of Miami and 55 miles southeast of Sunniland field. There is only about 230 feet of difference in structural depth of the Sunniland limestone between the two fields. Correlative data indicate about 11,340 feet subsea at Sunniland and about 11,100 feet subsea at Forty Mile Bend. Since the two fields are almost on strike, it seems justifiable to envision a trend or fairway on which they are the primary points of reference at present.

The second successful well at Forty Mile Bend, Gulf Oil Corporation et al State 1 went on production in April, 1954. Completion was from a coquina member of the Sunniland limestone. Initial production was 100 barrels of oil and 400 barrels of water per day on pump. Both wells were abandoned in 1955 after producing a total of 33,000 barrels. Only four wells have been drilled in the Forty Mile Bend Field to date, and the area is subject to several different subsurface interpretations that can only be resolved by further drilling.

Outlook for the future. Florida's oil future will be determined by further knowledge of the subsurface geology of the state, which in turn will be dependent on a stepup in deep drilling. It is well known that Tertiary limestones, in particular the Ocala, represent a very permeable acquifer that is interconnected through sinkholes to the surface virtually all over the Peninsula and is also exposed to the sea. It is very unlikely that oil will be found in Tertiary beds above a 30-foot thick anhydrite zone in the Cedar Keys section, which underlies altered conglomerates of the Oldsmar formation. The only well to give any grounds for optimism for production from beds younger than Cedar Keys age is the Amerada Petroleum Corporation number one Cole, in St. Lucie County near Fort Pierce. A show of oil was reported in basal Ocala limestone between 800 and 900 feet. However, the Cedar Keys anhydrite still appears to be the shallowest effective seal that can in places prevent the escape of hydrocarbons to the outcrop in Florida. The Cedar Keys dolomite immediately below the anhydrite is significantly the shallowest formation to record oil and gas shows, with the one exception of the Ocala in the Amerada well mentioned previously. Humble Oil & Refining Company twinned two of their deep wells near Sunniland with shallow Cedar Keys tests in apparent efforts to establish production therein. It is possible that in the future a "fairway" of Cedar Keys dolomite production might be established in South Florida, running roughly parallel to the south flank of the Ocala Highland, at depths somewhere between 3000 and 6000 feet. The same reasoning applies to a zone in the Fredricksburg section of the Cretaceous, which occurs at 9800 feet at Sunniland field. Most of the wells there have penetrated a consistent 50-foot thick zone of tight shaly limestone with oil and gas shows. Any Fredricksburg fairway, of course, would be expected to be deeper than a trend of Cedar Keys production.

The Oldsmar formation has been particularly troublesome to penetrate with the drill. Lost circulation has been experienced at as great a depth as 7000 feet in Monroe County. However, in the Sunniland "fairway" it appears that wells can be considered to be safely through the highly porous and troublesome surface limestones and subsurface conglomerates at 4000 feet. Once this zone has been penetrated and protection casing has been set and cemented, it might be possible to drill a slim (5-inch) hole to 12,000 feet as an exploratory Sunniland limestone test. If production were found, a four-inch liner might be run to the top of the pay, assuming the production would be similar to Sunniland where the oil will rise to 4000 feet or shallower from reservoir pressure. It could be pumped from this depth, which would also be the approximate depth of the casing shoe of the protection string. Later development wells could be of the full-hole production type. In this way, the cost of Sunniland limestone wildcat tests, which have exceeded $270,000 in the past *without* running a string of production casing, may be cut to $150,000 or less and make it more practical to drill.

An unfortunate thing about south Florida geology is that the greater thickness of evaporites is in the downdip direction, not the updip. Of course, this is to be expected. Were sufficient anhydrite deposited in the direction of the Ocala Uplift, probably much more oil would have been sealed off from escaping updip. A recent wildcat off the southern tip of the Peninsula, Gulf Oil Corporation State Tract 1 826 G encountered a thick section of anhydrite and a thin salt bed in the Sunniland zone, and correlation indicates a definite facies change from limestone to anhydrite south of the Sunniland field. If this facies change is complementary to, and thus ties in with, the geology of Eastern Cuba where Cretaceous limestones in the south grade into evaporites northward, it would appear that the Sunniland section may be expected to lose porosity south of its apparent "fairway" through a gradation into anhydrite.

ACKNOWLEDGMENT

The writer would like to express his appreciation to Joseph E. Banks, chief geologist, Coastal Petroleum Company, whose generous donation of his time and advice made publication of this article possible.

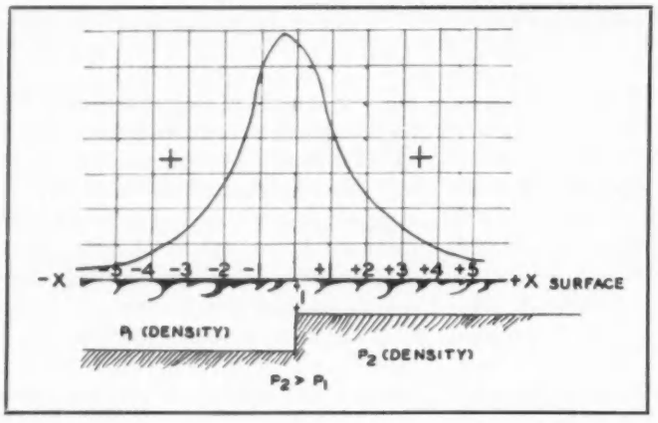


FIGURE 1—The relative magnitudes of vector gradients $\left(\frac{\partial 2U}{\partial z\,\partial x}\right)$ for two-dimensional vertical fault, where U = gravitational potential (after Jung).

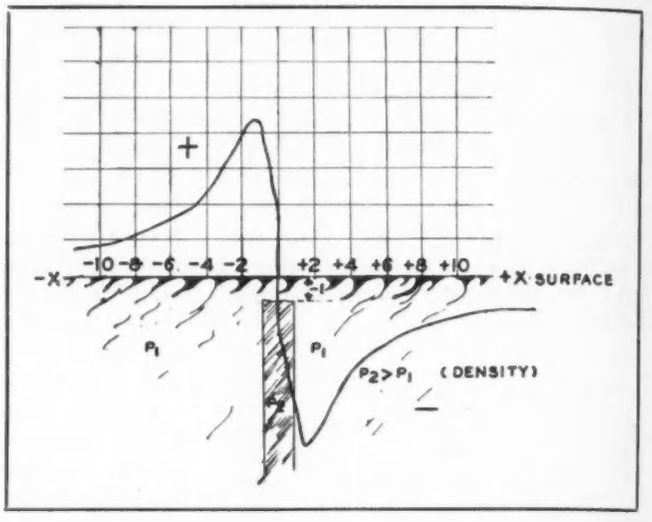


FIGURE 2 (Right)—The relative magnitudes of vector gradients $\left(\frac{\partial 2U}{\partial z\,\partial x}\right)$ for two-dimensional feature, where U = gravitational potential (after Jung).

Use of Gravity Meter as a Torsion Balance

Geophysical methods are recognized today as necessary and powerful tools in exploration for oil, minerals and elucidations of various problems usually met in geological engineering.

By V. G. GABRIEL
Houston

AT THE EARLY STAGES of the application of geophysical methods in the oil industry, the techniques were applied mainly on a grand scale for the location of the structures of relatively large closure and dimensions. The identification of faults and other minor structural and lithological phenomena have not been of critical importance in the past. Today, the exploration for oil is conducted in many areas where the structures with large closure and of extensive dimensions have been already mapped with the application of various geophysical techniques. Under these new conditions the identification of various structural and lithological phenomena, such as faulting, change in thickness and porosity of the formation might be decisive in selecting areas more desirable for leasing and locating a wildcat well.

Use of Variations in Density in Oil Prospecting. The variations in density, thickness, and geometry of the buried formations in the area under investigation, if properly mapped, serve as the reliable guides in the preliminary phases of drilling for oil. The gravimeter and torsion balance have been used for the evaluation of these guides, density in particular, during the last three decades; however, with the development of a modern gravimeter in about 1937 (U. S.), the use of the torsion balance in exploration for oil in the U. S. has been almost completely curtailed from about 1940 on account of its high cost of operation and slowness in comparison to that of the gravimeter.

It is of interest to note, however, that a few geophysicists in the past emphasized a somewhat greater significance of data obtained with the use of the torsion balance to those obtained with the use of the gravimeter. Evjen (1936) states: "The gradient map (obtained with T. B.), due to its better resolution and comparative absence of regional effects, often will be found to exhibit interesting features not apparent in the gravity meter." Klauss (1938, 1943) states: "The two instruments are not competitors, but have two different fields of application; the gravity meter should by all means continue to be employed as a rapid reconnaissance instrument, while the torsion balance, in its full resolving power, should be applied to the more detailed investigation of gravity meter anomalies" also . . . "In marked contrast to the role which regional effects play in total gravity work, the second derivative patterns (T. B.) suffer almost no deformation." Recently Nettleton (1956) states: "Torsion balance surveys were quite effective for determining the outline and thickness of caprock on shallow domes, as is shown by Barton's paper on this subject . . . It is

well known that the Torsion Balance is particularly effective in defining faults". . . .

Figures 1, 2, and 3 illustrate the ability of the torsion balance, properly handled, to delineate faults, volcanic plugs, certain type of salt dome, etc.

Figures 1, 2, and 3 show the relative magnitudes of gravity gradients $\left(\frac{\partial^2 U}{\partial z\, \partial s}\right)$ in crossing the idealized faults and a narrow two-dimensional feature respectively.

In Figures 1 and 2 the horizontal lines are the distances along the surface of the earth expressed in units equal to the depths of points K and K' respectively. The densities of the faulted formations and the narrow feature are greater than those of the surrounding formations.

Figure 3 gives a torsion balance anomaly $\left(\frac{\partial^2 U}{\partial z\, \partial s}\right)$ on Hull-Gloucester fault, Canada expressed in Eotvos (?) units.

It is of interest to note that Klauss (1938, 1943, 1945) has given considerable attention to the development of various techniques based on the torsion balance data for the identification of faults and other structures.

Use of Gravimeter as the Torsion Balance. It is a common knowledge that the gravimeter and the torsion balance are evaluating the different parameters of the gravitational field of the earth. The gravimeter gives the gravity (gs), or rather the difference in gravity between a base station and the point of observations. Analytically gs is written as $\frac{\partial U}{\partial z}$ where U is a gravitational potential. In general the torsion balance measures the following parameters expressed mathematically as $\frac{\partial^2 U}{\partial z\, \partial x}$, $\frac{\partial^2 U}{\partial z\, \partial y}$, $\frac{\partial^2 U}{\partial x\, \partial y}$, $\frac{\partial^2 U}{\partial x^2}$, $\frac{\partial^2 U}{\partial y^2}$. The parameters $\frac{\partial^2 U}{\partial z\, \partial x}$ and $\frac{\partial^2 U}{\partial z\, \partial y}$ are usually more dependable in many territories under torsion balance investigation. It is of importance however, to remember that the first two parameters can be transformed into one parameter such as $\frac{\partial^2 U}{\partial z\, \partial s}$ where "s" is any direction on an assumed datum level in the area under investigation. For final interpretation of the torsion balance data the parameters $\frac{\partial^2 U}{\partial z\, \partial x}$ and $\frac{\partial^2 U}{\partial z\, \partial y}$ are combined vertorially giving a certain direction "s," the direction of the maximum rate of change of the force of gravity g, or $\frac{\partial^2 U}{\partial z\, \partial s}$. The maximum rate of change in gravity is expressed in Eotvos units, where one Eotvos unit is equal to 1×10^{-9} of a Gal.

It is a common practice in the interpretation of the torsion balance data to transform the vector map, that is, the map on which the maximum rates of the change in gravity are plotted, into a gravitational contour map, somewhat similar to that obtained with the use of the gravimeter. By the same method of reasoning the gravitational contours obtained with the use of the gravimeter, can be transformed into a vector map giving the maximum rates of change in gravity.

Unfortunately this process of transformation, with a few exceptions, gives the vectors which faithfully represent the smooth idealized contours obtained with the use of the gravimeter and where the essential details leading to the identification of faults and other minor structural details are completely lost. However by making certain assumptions and by combining three adjacent gravimetric stations selected in accordance with their pattern of location, the maximum rates of change of gravity can be evaluated and plotted on the map, giving a picture somewhat similar to that obtained with the direct use of the torsion balance.

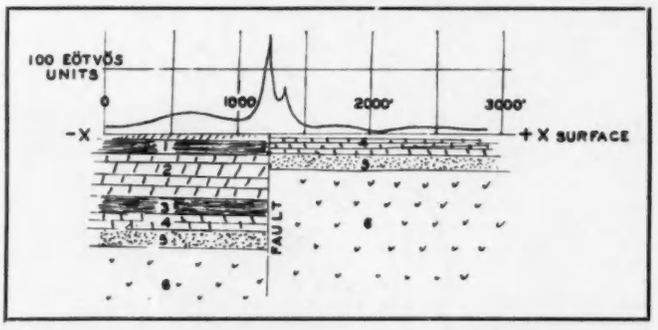


FIGURE 3—The magnitudes of vector gradients $\left(\frac{\partial 2U}{\partial z\, \partial x}\right)$ over vertical fault where: (1) is shale and limestone of density $P_1 = 2.6$; (2) is limestone of $P_2 = 2.7$; (3) is shale and limestone of density $P_3 = 2.5$; (4) is dolomite of density $P_4 = 2.8$; (5) is potsdam sandstone of density $P_5 = 2.5$; (6) is pre-cambrian of density $P_6 = 2.8$. (After A. H. Miller)

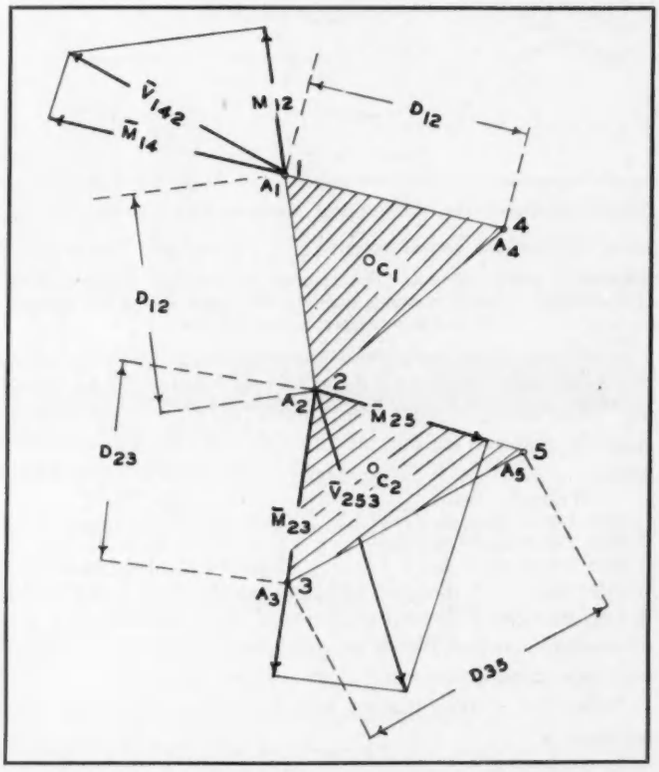


FIGURE 4—Transformation of gravimetric data into rate of change in gravity, so called, derived vectors, where: 1, 2 . . . . 5, gravimetric stations. A_1 . . . . A_5, corresponding gravitational anomalies expressed in 0.01 of a milligal. C_1 and C_2, the center of the triangles. V_{142} and V_{253}, the derived vectors.

Method of Transformation of Gravimetric Data into Rates of Change of Gravity Vectors. Given a certain number of gravimeter stations (Figure 4) and their gravity values, that is, their corrected differences between a base station and the observation stations. The gravity values A_1 . . . . A_5 are expressed in 0.01 of a milligal and written near their corresponding points of observation 1 . . . . 5. For the illustration of the method of evaluation

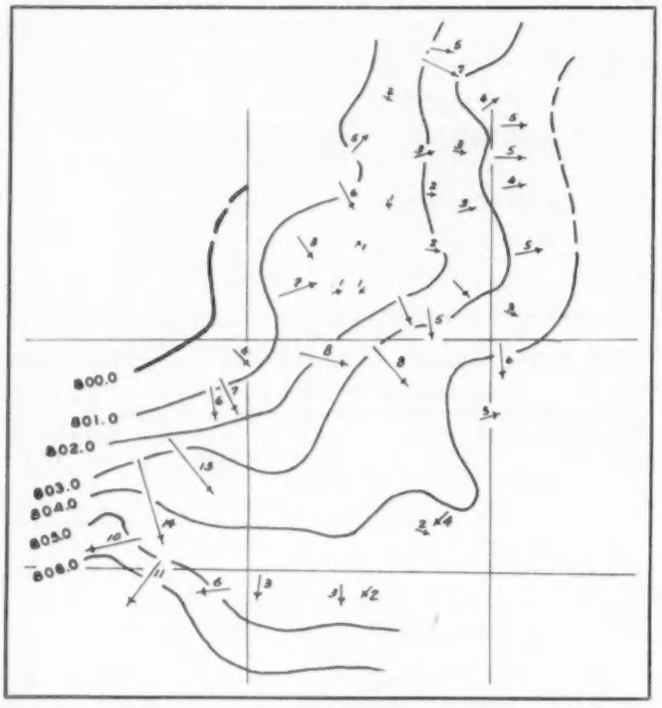


FIGURE 5—Shows the gravitational contours based on gravimetric survey. Each of the derived vectors $\left(\frac{\partial 2U}{\partial z\,\partial s}\right)$ is evaluated from a three gravimetric station triangle. The contour intervals are equal to 0.10 of a milligal. Vectorial numbers indicate the magnitude of the vectors in eotvos units per one centimeter.

of vectors construct two triangles 1-4-2 and 2-5-3 by joining with straight lines the points under consideration. Assume that by scaling off the sides of the triangles we have:

Triangle 1-4-2	Triangle 2-5-3
Side $1\text{-}2 = d_{12} = d_{21}$ (1a)	Side $2\text{-}5 = d_{25} = d_{52}$ (2a)
Side $1\text{-}4 = d_{14} = d_{41}$ (1b)	Side $5\text{-}3 = d_{53} = d_{35}$ (2b)
Side $2\text{-}4 = d_{24} = d_{42}$ (1c)	Side $3\text{-}2 = d_{32} = d_{23}$ (2c)

where: dij is the distance between points i and j expressed in centimeters. It is well understood that the distances are somewhat comparable in magnitude, at least within each separate triangle.

From the gravity values and Equations (1) and (2) we have:

$$\frac{A_1 - A_4}{d_{14}} = K_{14} \quad (3a) \qquad \frac{A_2 - A_5}{d_{25}} = K_{25} \quad (4a)$$

$$\frac{A_1 - A_2}{d_{12}} = K_{12} \quad (3b) \qquad \frac{A_2 - A_3}{d_{23}} = K_{23} \quad (4b)$$

where: Kij is the rate of change of gravity expressed in 0.01 milligals per one centimeter of the distance between points i and j. However, the *"K"* can be expressed in Eotvos units per one centimeter of distance in multiplying *"K"* by 10^4. The last number has been obtained from the following relationship:

1 gal = 10^9 Eotvos units (5a)
1 milligal = 10^6 Eotvos units (5b)
0.01 of a milligal = 10^4 Eotvos units (5c)

From Equations (3), (4), and (5c) we obtain:

$$\frac{A_1 - A_4}{d_{14}} = K_{14} = 10^4\,(K_{14}) = \bar{m}_{14} \quad (6a)$$

$$\frac{A_1 - A_2}{d_{12}} = K_{12} = 10^4\,(K_{12}) = \bar{m}_{12} \quad (6b)$$

$$\frac{A_2 - A_5}{d_{25}} = K_{25} = 10^4\,(K_{25}) = \bar{m}_{25} \quad (6c)$$

$$\frac{A_2 - A_3}{d_{23}} = K_{23} = 10^4\,(K_{23}) = \bar{m}_{23} \quad (6d)$$

where: $\bar{m}ij$ gives the rate of change in gravity expressed in Eotvos units per one centimeter of the corresponding lines and a bar (—) means a vector.

Plot the magnitudes of "$\bar{m}$" vectors (Figure 4) using appropriate scale, along their corresponding lines assuming:

$A_1 > A_4$ (7a)
$A_1 > A_4$ (7b)
$A_2 < A_5$ (7c)
$A_2 < A_3$ (7d)

Designating the line directions of vectors $\bar{m}_{12}$, $\bar{m}_{14}$, $\bar{m}_{15}$, $\bar{m}_{13}$ as S_{12}, S_{14}, S_{15}, S_{13}, respectively, we can express the magnitudes of the vectors as follows:

$$|\bar{m}_{12}| = \frac{\partial^2 U}{\partial z\,\partial s_{12}} \quad (8a)$$

$$|\bar{m}_{14}| = \frac{\partial^2 U}{\partial z\,\partial s_{14}} \quad (8b)$$

$$|\bar{m}_{15}| = \frac{\partial^2 U}{\partial z\,\partial s_{15}} \quad (8c)$$

$$|\bar{m}_{13}| = \frac{\partial^2 U}{\partial z\,\partial s_{13}} \quad (8d)$$

where:
U = Gravitational potential
| |, Means the magnitude of a vector

The examination of Equation (8) shows that analytically the "m" vectors are somewhat identical with the two torsion balance parameters designated as $\frac{\partial^2 U}{\partial z\,\partial x}$ and $\frac{\partial^2 U}{\partial z\,\partial y}$. Moreover, assuming that the magnitudes of the vectors expressed in Equation (8) are the components of their respective maximum rates of change in gravity, the directions and magnitudes of the respective maximum rates of change in gravity per one centimeter of the horizontal distance can be evaluated by intersection of two perpendicular lines, (as given in Figure 4). Vectors $\bar{V}142$ and $\bar{V}253$ should be plotted in the centers of the triangles 142 and 253 respectively because their computation has been based on three gravimetric stations comprising a triangle. The centers can be estimated graphically.

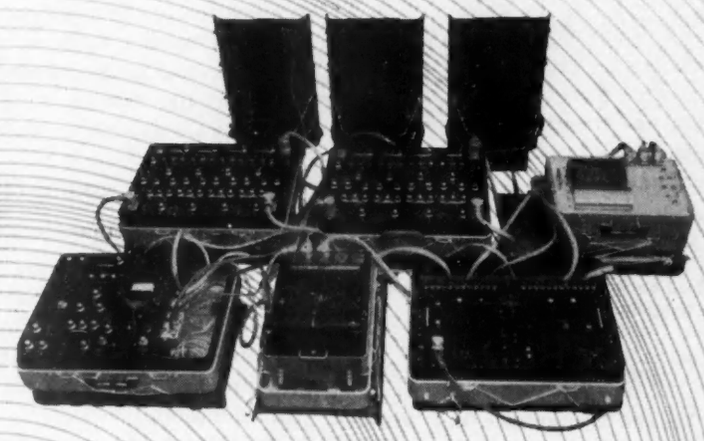
Figure 5 demonstrates the results of application of the method to a small gravimetric survey conducted in the U. S. and where no least square corrections have been applied to the derived vectors.

Least Square Technique for Adjustment of Derived Vectors. Designate vectors $\bar{V}_{123}, \bar{V}_{234}, \ldots \bar{V}_{ijk}$, of Figure 5 as vectors $\bar{V}_1, \bar{V}_2, \bar{V}_3 \ldots \bar{V}_n$, respectively. Join the points of application of the vectors by the straight non-intersecting lines (Figure 6). These straight lines may be combined into "m" triangles such as 123, 135, ... ijk. Assume any rectangular system XOY where the axes OX, OY can be chosen as parallel to the north-south and west-east lines, respectively. According to the last assumption the XOY rectangular system is NOE one.

Each vector $\bar{V}_i$, where i — 1, 2, ... n, can be decomposed into two vectors $\bar{V}_{iN}$ and $\bar{V}_{iE}$ parallel to the ON and OE axes, respectively.

Designate:

OE component of vector $\bar{V}_1 = \bar{V}_{1E}$ and its magnitude $|\bar{V}_{1E}|$ (9a)
ON component of vector $\bar{V}_1 = \bar{V}_{1N}$ and its magnitude $|\bar{V}_{1N}|$ (9b)
OE component of vector $\bar{V}_2 = \bar{V}_{2E}$ and its magnitude $|\bar{V}_{2E}|$ (9c)



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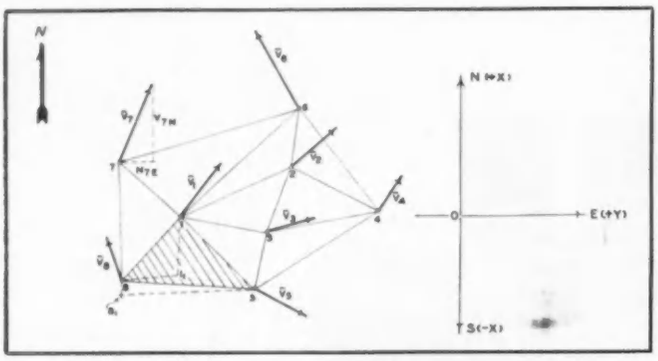

FIGURE 6—A set of triangles based on the map of the derived vectors for adjustment of the magnitudes of the vectors.

ON component of vector $\overline{V}_2 = \overline{V}_{2N}$ and its magnitude $|\overline{V}_{2N}|$ (9d)

- - - - - - - - - - - - -

OE component of vector $\overline{V}_n = \overline{V}_{nE}$ and its magnitude $|\overline{V}_{nE}|$ 9(n-1)

ON component of vector $\overline{V}_n = \overline{V}_{nN}$ and its magnitude $|\overline{V}_{nN}|$ (9n)

For each triangle two equations can be set pertaining to its north-south and east-west components. For triangle 815 the equations are:

$$(58_1)\ (+|\overline{V}'_{sE}|) + (81_1)\ (+|\overline{V}'_{sE}|) + (15_1)\ (+|\overline{V}'_{1E}|) = q_1 \quad (10a)$$

$$(88_1)\ (+|\overline{V}'_{sN}|) + (11_1)\ (+|\overline{V}'_{sE}|) + (55_1)\ (+|\overline{V}'_{1N}|) = p_1 \quad (10b)$$

where:

(58_1) and (88_1) are the east-west and north-south components of distance (58), respectively expressed in centimeters.

(81_1) and (11_1) are the east-west and north-south components of distance (81) respectively, expressed in centimeters.

(15_1) and (55_1) are the east-west and north-south components respectively, expressed in centimeters.

q_1, p_1 are the deviations from zero expressed in Eotvos units.

$$|\overline{V}'_{sE}| = \frac{-|\overline{V}_{sE}| + |\overline{V}_{sE}|}{2}; \quad |\overline{V}'_{sE}| = \frac{-|\overline{V}_{sE}| + |\overline{V}_{1E}|}{2}; \text{ etc.}$$

For "m" triangles we will have 2x m equations as follows:

$$a_1|\overline{V}'_{sE}| + a_2|\overline{V}'_{sE}| + a_3|\overline{V}'_{1E}| = q_1 \quad (11a)$$

$$b_1|\overline{V}'_{1E}| + b_2|\overline{V}'_{jE}| + b_3|\overline{V}'_{KE}| = q_2 \quad (11b)$$

- - - - - - - - - - - - -

$$m|\overline{V}'_{1E}| + m_2|\overline{V}'_{jE}| + m_3|\overline{V}'_{KE}| = q_m \quad (11m)$$

and

$$a'_1|\overline{V}'_{1N}| + a'_2|\overline{V}'_{sN}| + a'_3|\overline{V}'_{1N}| = p_1 \quad (12a)$$

$$b'_1|\overline{V}'_{1N}| + b'_2|\overline{V}'_{jN}| + b'_3|\overline{V}'_{KN}| = p_2 \quad (12b)$$

- - - - - - - - - - - - -

$$m'_1|\overline{V}'_{1N}| + m'_2|\overline{V}'_{jN}| + m'_3|\overline{V}'_{KN}| = p_m \quad (12m)$$

Where: $a_1, a_2, a_3, b_1, \ldots m_3$ are the east-west components of the corresponding sides of the triangles.

$a'_1, a'_2, a'_3, b'_1, \ldots m'_3$ are the north-south components of the corresponding sides of the triangles.

Solution of Equations (11) and (12):

In Equations (11) and (12) q_1 and p_1 are the sum of the errors, i.e., the total deviations from the true values, for a closed "i" triangle. Therefore Equations (11) and (12) can be transformed into 2m equations with 2n unknown $x_1, x_2, \ldots x_n$, and $y_1, y_2, \ldots y_n$, where $x_1, x_2, \ldots x_n$, $y_1, y_2 \ldots y_n$ are the corresponding errors in $|\overline{V}_{1E}|$ and $|\overline{V}_{1N}|$ magnitudes, respectively.

In solving the transformed equations the following considerations are of importance:

For n greater than m, the solutions of m equations will be of indeterminate character.

For n equal m, the m equations can be solved with the application of the theory of determinants.

For n smaller than m, the m equations can be solved with the application of the theory of least squares by normalizing the equations. The method of normalizing is given by Coolidge and other researchers.

Conclusions. A method of evaluating and plotting on the map of the derived vectors $\left(\frac{\partial^2 U}{\partial z\, \partial s}\right)$ is given, and the application of the least square technique for the adjustment of the vectors is briefly discussed.

A careful planning pertaining to the pattern and distribution of gravimetric stations is necessary if, both, the gravimetric maps and derived vector maps are under consideration.

In gravimetric surveys conducted on a large scale the application of analytical methods for the adjustment of derived vectors is necessary.

In gravimetric surveys conducted on a small scale an over-all visual inspection, without using an analytical method, might be sufficient.

The smaller the sides of the basic triangles in computing the derived vectors the more their magnitudes will approach the magnitudes of their corresponding torsion balance parameters. However the minimum permissible dimensions of a basic triangle are a function of the accuracy involved in carrying a gravimetric survey and in computing the data.

It would be of importance to check a few derived vectors with the use of the torsion balance in a convenient area.

It is of interest to note that Hammer (1953) and Nettleton (1956) in particular emphasized the importance of using very detailed gravimetric surveys for the evaluation of relatively small structures. Nettleton (1956) states: "It is well known that the torsion balance is particularly effective in defining faults . . . . The fact that, with adequate detail, a gravity meter survey can accomplish the same result, has had little attention in the geophysical literature."

Recently Thyssen-Bornemitza and Stackler (1956) have carried an experimental gravimeter survey for the evaluation of the rates of change in gravity in respect to a vertical direction. For that purpose readings at two levels separated by 12 feet approximately have been made at each gravimetric station.

ACKNOWLEDGMENT

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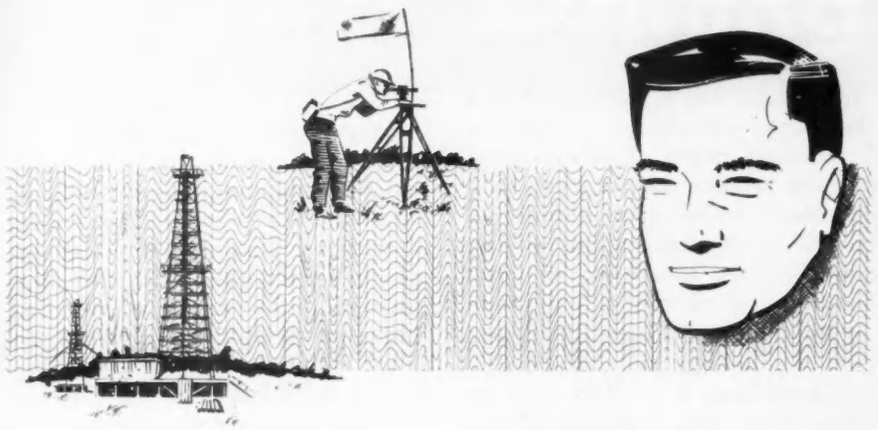

'Brain Waves'—Our Only Real Oil Finding Tool

One of the most important items in selecting or using any tool is that of figuring out its idea ratio so that the objective can be fully met.

By **JOHN M. PARKER,** Kirby Vensyn Petroleum Company, Denver

ALL DISCOVERED oil fields start out as an idea in one man's brain. Other men, or the same man, add more definitive ideas; the thoughts are put into action; and those all-important discovery wells are drilled and completed.

Geologists frequently fail to estimate the "idea ratio" of their oil-finding programs before they put them into effect. "We're spending $2 per acre to evaluate this acreage," is a common quote. Surface work, core drilling, magnetics, gravity, and seismic work are all computed at so much per acre and in terms of so much percent of an annual exploration budget. The selection of one or more of the above tools is based on a multiplicity of ideas. Too often these ideas are pushed aside and the final selection and application of the tool is based on cost-per-acre of evaluation. This is fatal to any oil-finding of the "evaluation" consists of covering an area with a control grid of so many points but doesn't come up with any drillable ideas. Many times a tool is chosen that has the lowest "idea ratio" and that tool may be the most expensive approach, so it certainly behooves us to think about the "idea ratio" first.

How do you evaluate the idea worth of your exploration program? How do you know before you try a certain approach whether you will obtain drillable ideas? Two rules to help answer these questions follow:

1. Call your shots ahead of time. There is nearly always a specific reason for going into an area and that reason is nearly always oil, either coming out of somebody else's discovery well, seeps at the surface, or oil-saturated outcrops. Don't forget that original motive. You may add to it; you may decide it is non-commercial; but don't forget you are aiming at a target; call your shot.
2. Work an area from top to bottom and from the outside in. Regardless of the tools you are using, avoid one-shot ideas or horizons. You may say this rule conflicts with rule No. 1. It doesn't, since you obtain much better geology on one layer when you work all layers simultaneously. After all, they are intimately related—in bed with each other, so to speak. In addition, you will obtain new ideas that will allow you to expand or change your original program to cover multiple oil-bearing objectives. Another reason for working an area from top to bottom is that it is most unusual for an area not to have more than one pay horizon.

To illustrate, many are familiar with the common experience of going into an area just because "it's a good basin," and then of having several surface parties work in that district for months. They turn in a map showing regional dip (but no regional cross sections showing the full stratigraphy on both sides of that basin and no regional structure sections). Everybody agrees, pull them out, let's shoot it. Several seismic crews burn up hundreds of tons of powder; they come up with a slightly steeper regional dip gradient map, sprinkled with a few low-powered structural noses and weak closures which look like computational buckets of guts. Pull 'em out. You drop your leases and two years later along comes a discovery right next to or right under where you expended all that effort.

Rules 1 and 2 weren't applied. You may even have drilled a wildcat and passed up a pay zone on the way down to what you hoped was the producing horizon. You didn't do your work from top to bottom. An exploration program should be set up to yield the most ideas-per-dollar, not on the cheapest cost-per-acre basis using some method that worked somewhere else 15 years or even 15 months ago.

To be more specific in respect to idea ratios, suppose you decide that a ten-hole strat hole program is what is required to find a drillable prospect based on a specific idea. The normal routine is to dig the holes, collect ditch samples, run electric logs and then look for the drillsite based on that information. If you followed the normal routine, you didn't obtain the most ideas per dollar! Almost certainly you would have obtained more and better drillsites if you had taken cores (assuming you were drilling to the objective zone) or if you had run dipmeter surveys in all of the holes (assuming you were in a steep dip and/or faulted area). But, you object, those items run the cost up too much. You're wrong; they run the cost per foot up, but you're not looking for feet—you're looking for oil, and those extras make the cost of finding oil go down. Your program would have been better had you drilled 8 or 9 holes with cores or dipmeters at exactly the

same cost that you drilled 10 holes without those idea-making extras.

If the decision is made to use the nine-hole program with cores of the potential producing zone, you are set up to obtain ideas, but "well conceived and poorly executed" still loses many oil fields. Too many of our companies still put young inexperienced men out to sit on wells. Frequently the basic well information tabulation or interpretation which will result in new ideas is relegated to a centralized research team which is so far removed from the play that they forget they are looking for oil; the space separation and time lag kill the whole program.

Paul Weaver in the AAPG presidential address titled "Geological Interpretation of Exploratory Wells," asks the following questions in regard to a wildcat:

"Are there shows of oil and gas, in what kinds of formation, and of what age? Does drilling confirm the existence of a favorable structure? How is the well situated on that structure? . . . What are the reservoir rocks? . . . are the data from logs and cores adequate to give us evidence of favorable reservoirs nearby, which are not favorable in the well itself?"

Answers or partial answers to all of those except the last question are commonly obtained. The answer to that last question is, in many cases, affirmative; we just don't use the data.

Assume that this nine-hole program is to find the updip termination of a sand that has had shows in it and is known to occur erratically above an unconformity. It is believed that the sand transgresses time lines and that it is distinct in origin from another similar sand that occurs below the unconformity zone. To prove or disprove these suppositions (which you must do in order to make accurate sand maps) and to locate the nine holes where they will do the most good, you decide to drill four holes in a square and another hole in the center of the square.

On the basis of these five holes, you will contour the results in the form of isopachs, facies maps, and structure maps, and the final four holes will be target holes aimed at specific oil-holding anomalies shown on the maps prepared. You decide that you will need micropaleontological work to determine whether any sands that you core are from above or below the unconformity.

In addition, the faunal assemblages may tell you something of the nature of the sand origin. You also need grain size analyses and heavy mineral assemblage identifications to make an accurate facies map and so you can hypothesize the existence of facies changes in the vicinity of well bores.

With good organization, all of these items can be achieved immediately after each core is pulled, not six months later. You will also achieve ideas with stress on oil-finding if you put the fact sorters in the field and make them responsible for those next locations while the rig is standing there and before that next group of delay rentals payments come due. (Or before your competitor leases some of the open acreage just on general principles.)

If you plan a program as set out above, you may be greeted with howls of protest from the hidebound: "we set up our researchers, micropaleontologists, sedimentation specialists, etc., in a central laboratory because there they can service everybody in the company at their convenience, they can have the best laboratory equipment there, it's cheaper to centralize, and so on." Rubbish. Do not confuse long-range basic research with oil-finding right now. Both are necessary, both should work together. But don't sacrifice one at the expense of the other. The two most expensive and complicated tools that we have in the field today operate under very stringent time schedules. Those two tools are the rotary drill and the seismograph.

If it can be done with those tools, surely we can put a man with some sieves and graph paper, an extra microscope, some type foraminiferal suites, and an extra notebook in the field. If a mass spectrographic analysis is called for, the cost of air express on a sample can to the central laboratory will not be prohibitive. All of this set up will cost more money than you have been spending on a so-called routine wildcat.

However, remember that you are conceiving ideas to find oil, and those ideas will result in a few pencil point targets on maps which means that you will spend less money in drilling on many vague targets. It is the drilling of many wells on vague targets that sends the cost of finding a barrel of oil skyrocketing.

Turning to another example where you are concerned with a strictly structural problem and the seismograph seems to be the best tool to use. Regional dip is to the west in this area and you believe that a series of west-east lines are the best approach to delineate structure. Unfortunately, the terrain is such that only north-south lines may be obtained with ease. Generally speaking, it takes much less control to delineate structure, both regional and anomalous, by shooting dip lines and you will be way ahead in both time and money by dozing west-east roads.

Another frequent hazard encountered when seismic work is done for structural control is that of not obtaining deep enough reflections. How many times have we seen seismic programs limp along for months in areas where reflections were not being obtained as deep as the primary objective horizons and where there are known interval changes in the area occurring between the reflection horizon and the primary oil horizons. Possibly a change in shooting technique will give you reflections that will give positive structural control at the horizon you want to drill to.

If the change in technique doubles the cost of your shooting, you may want to shoot only half as much area or you may want to pull out of the area altgether. The time to make such decisions is when you first initiate a shooting program. Remember, call your shots. Ghostly ideas based on a shallow reflection horizon may be helpful if you don't get too many at too great a cost. This conversation, however, is concerned with specific ideas that will result in a drillsite or in drillsites that will check a specific idea.

Do not forget that the answer to the question: *"What is a drillsite?"*— is complex. Levorsen spelled it out very well as follows. "The answer to the question 'What is a prospect?' combines geology, economics and many personal attitudes in an almost infinite number of combinations and variations. Each prospect is geologically unique and is generally marked by some anomalous variation in an otherwise regular geologic feature. In addition, each prospect has a different value and appeal to every operator considering it." —**The End**

Formation Evaluation by Log Interpretation

A new method of determining well productivity from electric logs based on the determination of relative permeability to the various reservoir fluids.

By S. J. PIRSON
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The University of Texas
Austin

THE INTERPRETATION of electric, radioactivity and other well logs has heretofore been limited to the determination of formation water saturation as the ultimate goal. This has left to the judgment of the interpreter, or that of the well operator, the decision as to whether or not certain horizons in the well should be drillstem or production tested.

It is the purpose of this study to show that the job is only half done once the formation water saturation has been determined, and the main part of the log interpretation work is yet to be done. Conclusions must then be drawn concerning the well productivity. This requires ascertaining the irreducible water saturation, the expected water-oil ratio, the daily rate of oil production and the expected ultimate recovery of oil and gas per well. The seriousness of the problem may be realized when one observes that well productivity ranges from clean oil production from the Olmos sand (Upper Cretaceous) containing as much as 80 percent connate water saturation to clean water production from the Springer sand (Pennsylvanian) computing as little as 25 percent water saturation by standard log interpretation techniques.

The comprehensive evaluation of the productive potentialities of a specific formation entails the determination of the following in each well:

1. Effective Pay: h_e: this is the total porous, permeable and oil saturated section of the reservoir.
2. Porosity: ϕ: or void volume per unit rock volume.
3. Connate water satuation (S_{wc}), including the breakdown into non-movable water (ϕ_h) and movable water (S_{wm}).
4. Specific permeability: (K) or ability of the reservoir rock to transmit fluid under application of a differential pressure.
5. Relative permeability to the wetting (k_w) and non-wetting phases, (k_{nw}) or the relative ability of the various fluids to flow simultaneously through the reservoir rock.
6. Expected reservoir fluid properties: β_o, μ_o, μ_w, μ_g: which are respectively the reservoir volume factor for oil and viscosities of oil, water and gas. Also reservoir pressure (P_o).
7. Water-oil ratio (WOR) or water-gas ratio (WGR).
8. Recoverable oil and/or gas and ultimate recovery per acre-foot. (STO/AF) or (MCF/AF).

For the purpose of comprehensive log interpretation, reservoir rocks are divided into four classes:

I. Clean water-wet rocks of intergranular porosity.

II. Shaly water-wet rocks of intergranular porosity.

III. Oil-wet rocks of intergranular porosity.

IV. Rocks with multiple type porosity: water or oil-wet.

Continued on Page 161

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Part 1: Interpretation of Well Logs in Clean Water Wet Rocks of Intergranular Type

A WATER-WET ROCK is one in which the position of water within the pore space is preferentially such that it is attached or adheres to the mineral framework of the rock. Most log interpretation techniques have been designed for water-wet rocks of intergranular type porosity. This type of rock may be recognized from formation samples but in their absence there are certain characteristics of the electric logs which are helpful in recognizing that the reservoir rock is of this type. If formation water resistivities are known at a particular level, the self potential (SP) deflections after appropriate corrections should check theoretical predictions. A different manner of expressing the same thing is to say that there is *no reduced* SP deflections. A typical characteristic of water-wet rocks is that they exhibit a resistivity gradient provided the latter cannot be ascribed to lithological or wettability changes or to multiple shielding. Such a gradient is then the result of capillary distribution of water in a water transition zone. Obviously capillary water can only be held in such distribution in a water-wet reservoir rock.

1. Effective Pay. Best techniques to evaluate effective pay from logs are from the SP curve and from micro-logging devices. Core analysis, when complete core recovery is obtained, is, of course, helpful, but this study is beyond the scope of this series.

The SP curve, though not a measure of the actual magnitude of porosity, is an indicator of the existence of porosity at various levels. When fresh muds are in the well bore, i.e., when $R_{mf} > R_{we}$, any SP deflection trend of a negative character is indicative of a porous zone. The individual thickness of each zone may thus be ascertained by the vertical spacing between SP inflection points. Thereby, the SP curve provides a means to make a "sand count," i.e., to evaluate effective pay. (h_e)

Micro resistivity logging devices (micro-logs, contact logs, micro resistivity logs) are essentially mud-cake detectors. Under the excess pressure of the mud column which normally exists over formation pressure while drilling, infiltration of mud filtrate takes place into the formations that are sufficiently permeable to allow it. Conversely, such formations, if they contain hydrocarbons, should be sufficiently permeable to permit commercial production. Hence, any formation exhibiting a mud-cake as detected by micro resistivity tools should be considered as *effective pay.*

A further confirmation of the findings of the micro tools is supplied by the micro-caliper which provides positive mechanical evidence of the existence of a mud-cake when the well is drilled to bit size, as is often the case in sandstone and carbonate reservoir rocks.

2. Porosity. Porosity of formations of interest may be obtained from a variety of well logs and techniques, but it is advisable to verify the results of one against those of another and thereby arrive at more dependable and trustworthy results. In all of the future petrophysical calculations, an accurate knowledge of porosity is paramount.

(a) Porosity may most dependably be determined from microtools, i.e., from those with short radii of investigation and which essentially probe only within the flushed zone. Such tools are the micro-log, the contact log, the micro resistivity, the micro-latero-log and the micro-neutron logs.

Micro resistivity tools must be calibrated in order to obtain their response to porosity and formation factor because their readings depend on the mechanical fit of the insulating pad that supports the electrodes as well as on the size of the pad and on the position of the electrodes. Logging service companies supply such information.*

Micro-neutron logs provide a direct measurement of porosity and the curves obtained by means of this tool are directly calibrated in porosity values. The results seem dependable when the mud-cake is not too thick. At this writing this tool has been withdrawn from service.

(b) Next in order of accuracy with respect to porosity determination is the limestone curve. The limestone logging device is a resistivity measuring tool composed of two short laterals in parallel. This device has a very short radius of investigation, (of the order of 20 inches) and the probing distance may be considered to be altogether within the *flushed* and the *invasion zones* combined. The limestone curve in a medium of infinite resistivity has the desirable property of current saturation, i.e., it deflects to a maximum and finite value which is considered as the base line of zero porosity. For deflections of lesser magnitude than this base line and for non-shaly beds, existence of porosity is indicated. Calibration

* Schlumberger Log Interpretation Charts: C_2, C_4, C_8, C_{10}
Halliburton Charts for Log Interpretation: 5, 6a, 6b, and 8
PGAC Quantitative Log Analysis Handbook: 10 and 11
Elgen Log Interpretation Manual: PL 1, 2 and 3

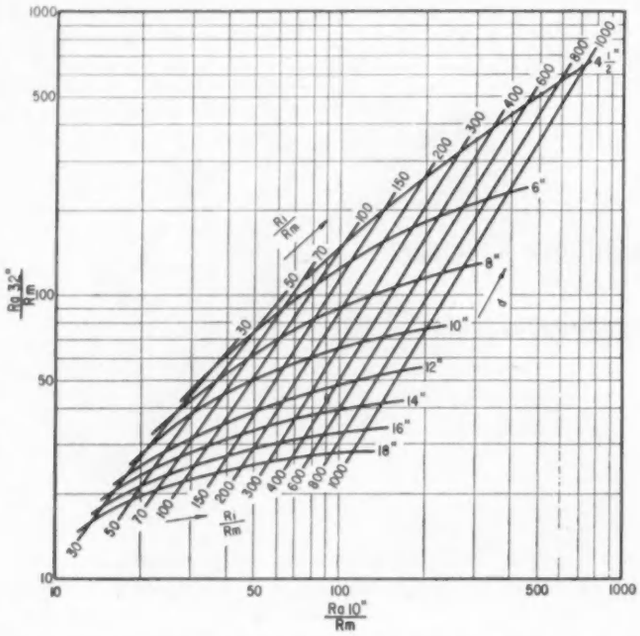

FIGURE 1—Chart for determination of Ri and d from a combination short normal (AM = 10") and limestone curve (LS32").

curves for porosity determination are available and vary with hole size. In order to eliminate errors which result from hole enlargement or constriction, it is advisable to combine the limestone curve with a curve of similar radius of investigation but of different departure characteristics with respect to hole size. Such a curve is a short normal of 10-inch spacing (AM = 10 inches). This curve is always run in conjection with the limestone curve. By combining the departure curves of the logs, a set of curves results which permit to determine uniquely the values of R_i/R_m and of hole size (Figure 1). Once R_i is known and by making judicious assumptions concerning the residual oil or gas saturation in the invaded zone and concerning the mixing of mud filtrate and formation water in the invaded zone, reasonable values for formation factor and porosity are obtainable.

(c) Next in order of accuracy for porosity determination is the *short normal curve* (AM = 16 inches or 2 Z 18 inches) and is to be used only when no microtool log or limestone curve is available. This is a last resort procedure. Before using the technique one must ascertain that there is sufficient depth of invasion by mud filtrate and that the short normal does not record nor is affected by R_t. Then a value of R_i/R_m is obtained after correction of the short normal for bore hole effects. Porosity is readily computed from R_i. Figure 2 provides such a means for rapid evaluation of porosity. This graph is especially designed for limestone and highly consolidated reservoir rocks. A similar procedure is followed when applying PGAC Chart 14.

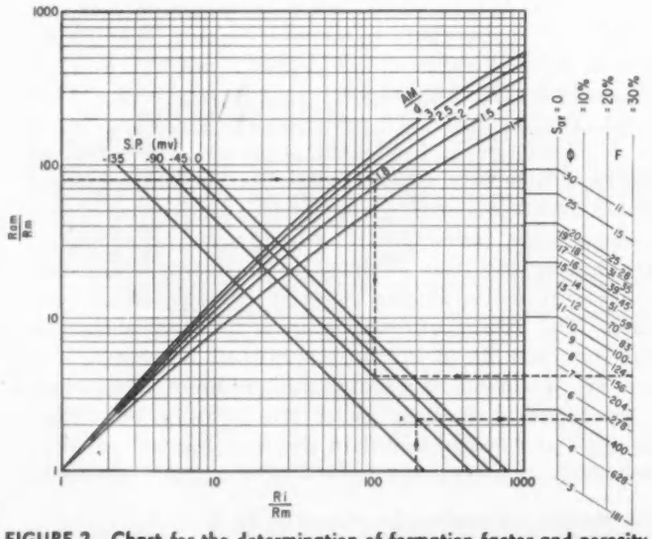

FIGURE 2—Chart for the determination of formation factor and porosity from a short normal curve or from $Ri/_{Rm}$.

(d) Of a different nature is the *neutron curve* which also provides a dependable means of porosity determination provided the formations are not shaly. Means for taking into account the shalyness of the formation and for making the necessary reductions are, however, available. In the main the neutron curve requires regional calibration for porosity determination in carbonate rocks. It is not as yet generally applicable to clastic sediments.

Figure 3 permits the direct determination of porosity from the recorded neutron-gamma counts per second on a Schlumberger radioactivity log. Depending on whether the hole is empty (gas drilled), filled with fresh mud or with salt mud, the neutron response to porosity is different because of the absorption of neutrons by chlorine ions and by the hydrogen of the mud water. Neutron response is also affected by hole size. All these variations are provided for in the center scales of the chart. To obtain porosity from a Schlumberger neutron curve enter neutron reading on the left scale and join it to an appropriate point on the center scale selected according to hole size and type of mud. Porosity is obtained directly by extending the straight line to the vertical scale on the right. For neutron-gamma curves of the type obtained by Well-Surveys licensees (Lane Wells, Western Company, Welex Company) the "Preliminary Neutron Curve Conversion Charts" published by Lane Wells give a means of converting the neutron deflections to porosity.

For neutron-neutron curves of the type obtained by PGAC, the latter company's Chart 15 permits porosity determination. Halliburton recommends the Radiation-Guard Log combination particularly in limestone reservoir rocks (Kansas and Permian Basin).

(e) *Acoustic Logging* provides a new and independent means of porosity determination. The technique is not widely used presently as a porosity logging device. Its main use is as a continuous acoustic velocity device and the results are mainly used in seismic interpretations. Commercial logging companies are expected to place the instrument on the market in the near future strictly for porosity logging in conjunction with electrical and radioactivity logging.

(f) *Indirect Means* of determining porosity exists in methods of log interpretation that first determine fluid saturation, then porosity. Such techniques are the *Tixier (Rocky Mountain) method* and the *R_i method.* (Schlumberger charts D_s and D_p, Elgen Chart Q_3).

It goes without saying that the porosity value involved in this discussion is the true value, i.e., that which exists in place under the prevailing reservoir conditions.

3. Water Saturation. Formation water saturation may

be obtained from a variety of techniques in *clean rocks:* Archie, Tixier (RM), and R_i methods.

The oldest of the techniques is due to Archie.[1] In its original form it makes use of the formula:

$$S_{we} = \sqrt[n]{\frac{R_o}{R_t}} \qquad (1)$$

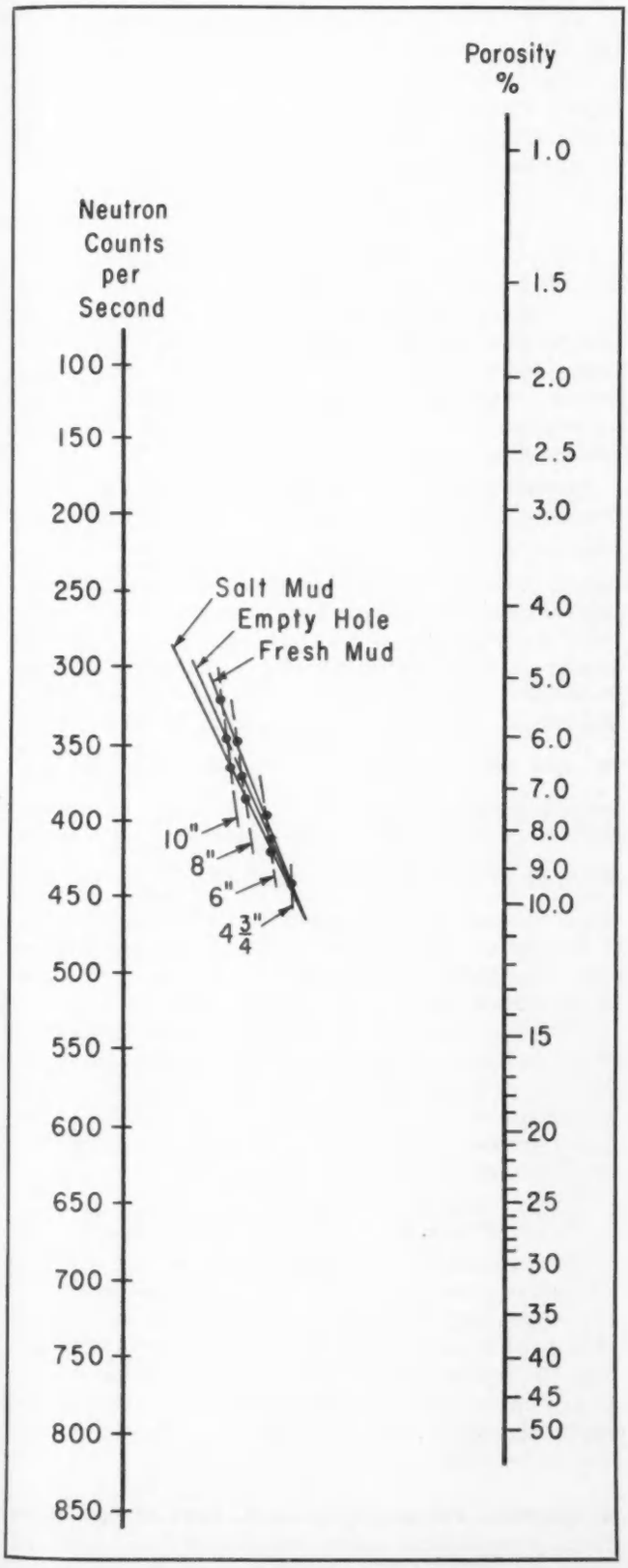

FIGURE 3—Schlumberger calibration of counts of neutron versus porosity.

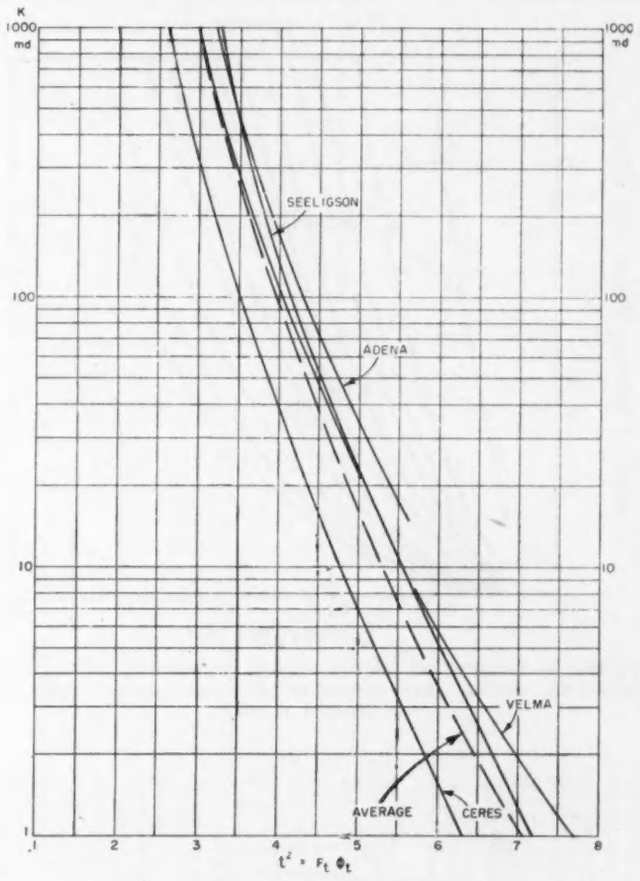

FIGURE 4—Permeability—tortuosity correlation.

where R_o is read in a well defined salt water bearing horizon.

R_t is the true resistivity of the object formation.

n is the saturation exponent, generally taken to be 2. In many instances R_o may not be read from a log and it is necessary to compute it from:

$$R_o = FR_{we} \qquad (2)$$

where the formation factor, F, is obtained from porosity methods and R_{we} is either known from formation water samples, or formation water maps, or it is calculated from the SP curve. All service logging companies handbooks have charts that permit rapid solutions of Equation (1) in all its forms.

The *Tixier (Rocky Mountain) method* was developed because of the difficulty of obtaining F especially when formation waters are relatively fresh as is the case in the area where this technique originated. This technique uses in combination three curves: SP, short normal and lateral. In effect, it is a comparing technique for the three curves, or it is tantamount to the simultaneous solution of three equations representing the three curves. (Schlumberger Chart D_8; Elgen Chart Q_3).

The *R_i method* is a last resort technique used when the value for R_t may not be read from any of the curves but when a sufficient depth of invasion is present. (Schlumberger Chart D_9).

4. Specific Permeability. Specific permeability or permeability of a unit volume of reservoir rock may be ascertained from electric logs by petrophysical correla-

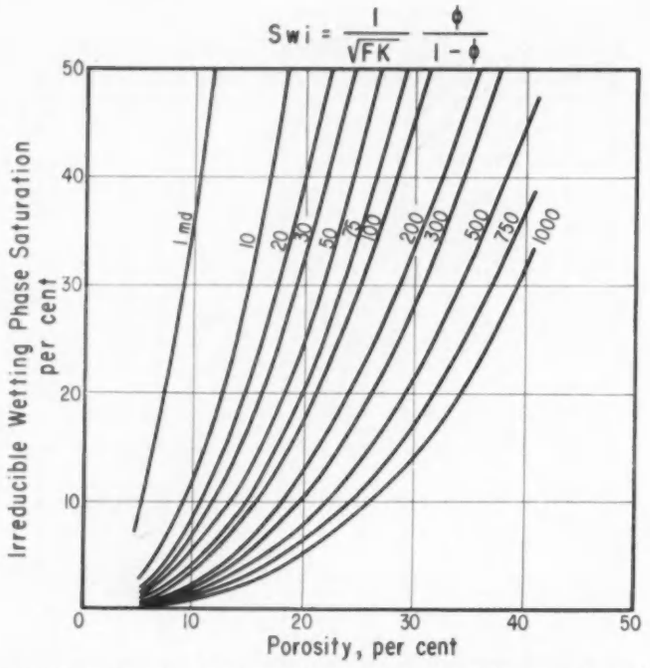

FIGURE 5—Petrophysical relation between permeability, porosity and irreducible wetting phase saturation in clean reservoir rocks of intergranular porosity.

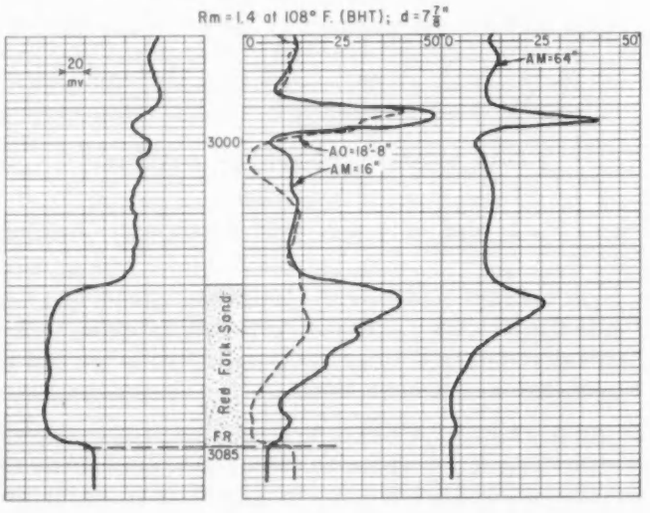

FIGURE 6—Example 1—Electric log in clean, water-wet reservoir rock of intergranular porosity showing resistivity gradient in a water saturation transition zone.

tions of various kinds or from logs exhibiting a well defined resistivity gradient not lithological in character.

Permeability correlations with other petrophysical characteristics are of various kinds. A *correlation with formation factor (F) and porosity* (ϕ) is shown in Figure 4. F may be known from core samples, from porosity measurements and lithological descriptions or from direct evaluation on the log from a zone of 100 percent brine saturation and provided the brine salinity is known. Porosity may be known from drill cuttings, cores or from various log methods of determination. Another *petrophysical correlation* is used by Schlumberger (Chart E_4) which relates water saturation, porosity and permeability by the empirical formula:

$$K^{1/2} = 250\ \frac{\phi^3}{S_{wi}} \qquad (3)$$

Still another *correlation based on Kozeny's equation* and following the establishment of a correlation coefficient for some well known water-wet sands is

$$K = \frac{1}{F}\left(\frac{\phi}{1-\phi}\right)^2\ \frac{1}{S_{wi}^2} \qquad (4)$$

This latter correlation is plotted in Figure 5, making use of the Humble relation $F = 0.62\ \phi^{-2.15}$; it is in many respects, similar to the Schlumberger correlation. Knowing ϕ and S_{wi}, K may be obtained or conversely when ϕ and K are known the irreducible water saturation (S_{wi}) for a clean rock, is ascertained. This saturation is at times called the "critical water saturation" for any higher water saturation will be partially movable and under production test, a water-cut will be obtained with the oil. The mobile water saturation is

$$S_{wm} = \frac{S_{wc} - S_{wi}}{1 - S_{wi}} \qquad (5)$$

Order of magnitude of the specific permeability may also be approximated when the deep penetration (lateral) resistivity curve exhibits a *resistivity gradient with depth.* This method due to Tixier is based on a correlation of permeability, capillary pressure and differential density between water and hydrocarbons. An example of such log is given in Figure 6. Schlumberger Chart E_2 provides a solution for the problem.

Another approach to the determination of specific permeability from electric logs and from their *relation to capillary pressure* is through the formula $P_c = (2/\bar{r})\ \gamma \cos \Theta$, $\bar{r}$ being the mean capillary radius in which a capillary suction P_c (dynes·cm^{-2}) is exerted by a wetting fluid, the wettability of which is expressed by $\gamma \cos \Theta$ in (dyne·cm^{-1}). If the resistivity R_o in a water saturated section and if R_{ti} at the irreducible water saturation level and known, the mean capillary radius ($\bar{r}$) of the capillaries can be shown to be proportional to $\frac{R_{wc}^2}{R_o R_{ti}}$. Since petrochemical relations indicate that specific permeability is proportional to $\bar{r}^2/F$, it is concluded that permeability should be proportional to $\frac{R^2_{wc}}{F R_o R_{ti}}$. However, the coefficient of proportionality involved is a function of relative wettability of oil and water for the reservoir rock. The latter changes with the API gravity of the oil, the formation temperature and the gas in solution in the oil. The latter is mostly a function of pressure, therefore, of depth. An empirical relationship for this variation was determined from relatively few data; therefore, the following proposed relationship is tentative only and requires further confirmation. The tentative specific permeability formula is as follows:

$$K = \left(\frac{850{,}000}{\text{API Gravity}} - 3.5\ \text{Depth in ft.}\right)\frac{R^2_{wc}}{F R_o R_{ti}} \qquad (6)$$

The permeability is obtained directly in darcy. The formula was obtained by multiple correlation studies of a few wells and, therefore, it is limited in its scope. It should not be used for high gravity crudes (API $> 40°$) and for depths greater than 6500 feet. When more is known about the variation of interfacial tension with depth and with types of crudes, an improved formula may be derived.

5. Relative Permeability and Well Productivity. From petrophysical considerations and from reasonable concepts relative to the distribution of the wetting and

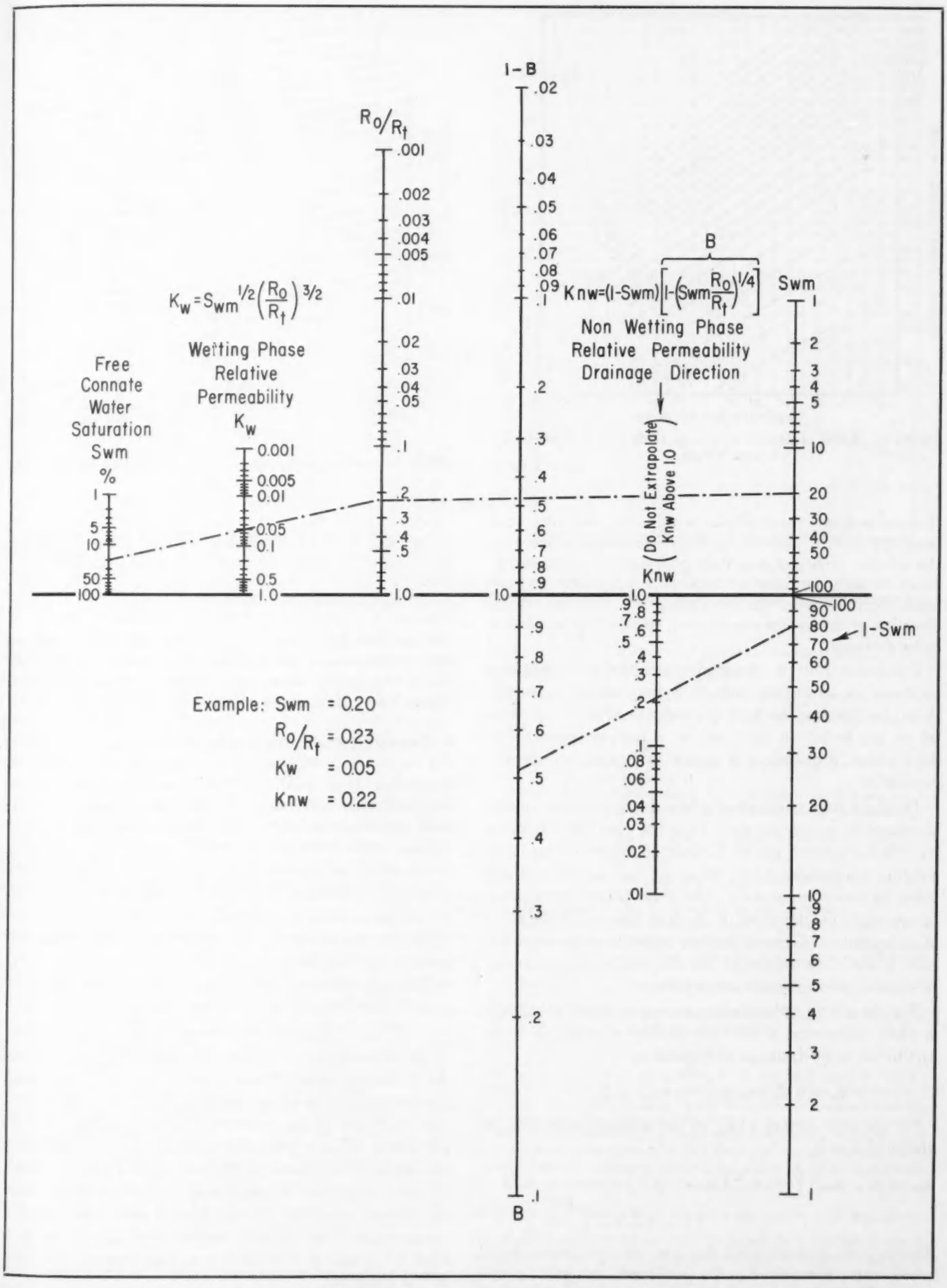

FIGURE 7—Nomograph for calculating relative permeabilities from electric logs. This nomograph permits a rapid solution of the wetting phase relative permeability and the non-wetting phase relative permeability for intergranular porosity only.

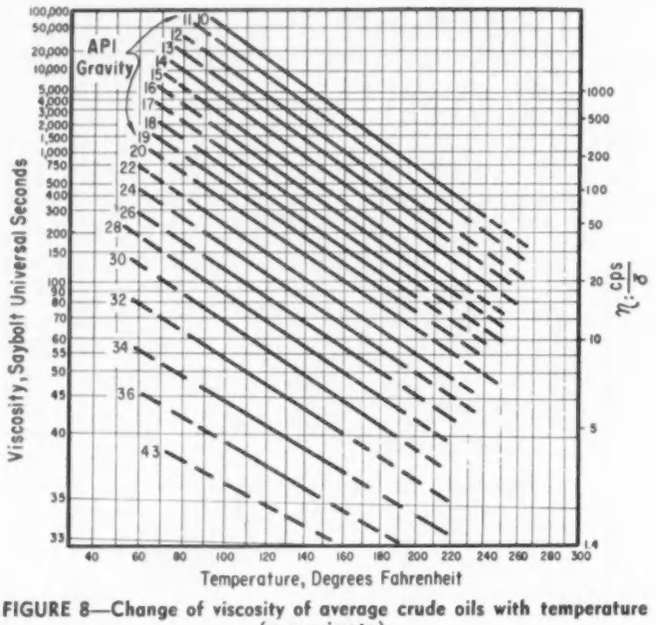

FIGURE 8—Change of viscosity of average crude oils with temperature (approximate).

After W. L. Nelson

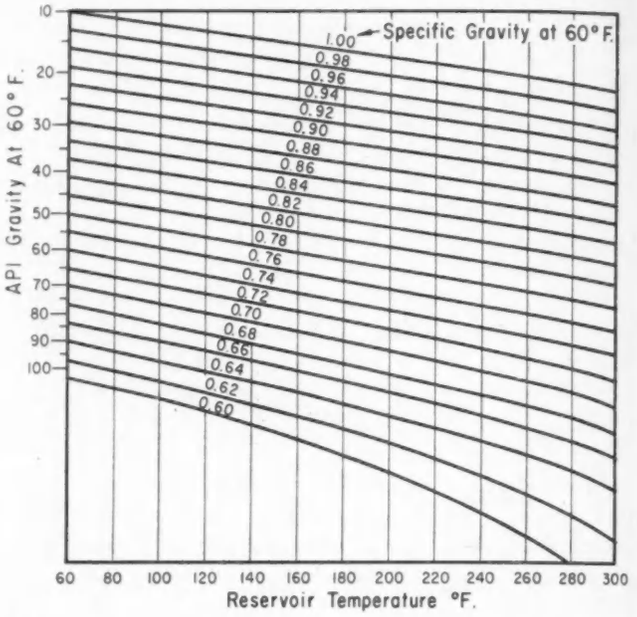

FIGURE 9—Average gravity—temperature relationships for crude oils.

the non-wetting fluid phases within the reservoir rock pore space, it is possible to derive relations concerning the relative ability of two fluid phases to flow simultaneously through the reservoir rock. It is recognized that the fluid distribution in the pore space is a function of the direction of saturation change, i.e., whether by *imbibition* or by *drainage*.

Imbibition flow is obtained when the wetting phase increases in saturation such as is the case for a water-drive. In this case, back of the water-flood front, residual oil or gas is left in the form of a trapped phase. The fluid phase distribution is essentially coaxial in the capillaries.

Drainage flow is obtained when the non-wetting phase increases in saturation such as is the case for gas drive by either dispersed gas as a result of release of gas from solution (depletion drive) or as a result of frontal gas drive (gas-cap expansion). The fluid phase distribution is essentially in the form of channel flow or in the form of independent filament flow in individual channels for each phase. The results of the theoretical computations of relative permeabilities are as follows:

For the *wetting phase*, experience has shown that there is little difference in its flow ability whether it is by imbibition or by drainage. It is given by:

$$k_w = S_{wm}^{\frac{1}{2}} (R_o/R_t)^{3/2} = S_{wm}^{\frac{1}{2}} \; S_{we}^{3} \qquad (7)$$

For the *non-wetting phase* in the drainage direction, its ability to flow is

$$k_{nw} = (1 - S_{wm}) \left[1 - S_{wm}^{\frac{1}{4}} \left(R_o/R_t\right)^{\frac{1}{4}}\right]^2 = (1 - S_{wm}) \left[1 - S_{wm}^{\frac{1}{4}} S_{we}^{\frac{1}{2}}\right]^2 \qquad (8)$$

This is the formula used for gas relative permeability when water is expected to be produced with gas.

For the *non-wetting phase* in the imbibition direction, its ability to flow is

$$k_{nw} = (1 - S_{wm} - S_{nwt})^2 \qquad (9)$$

where S_{nwt} is the trapped non-wetting phase saturation which may be estimated from microtool resistivity by

$$S_{nwt} = 1 - \frac{1}{\phi\,(1 - S_{wi})} \; (R_{mf}/R_{xo})^{1/2} \qquad (10)$$

Formulae (9) and (10) are to be used for oil permeability when water is expected to be produced with oil under the action of a water-drive. The nomogram of Figure 7 permits a rapid solution of equations (7) and (8).

6. Expected Fluid Properties. Naturally, fluid properties required in flow studies in porous media are not obtainable from well logs and it is necessary to have available such information from other sources. However, fluid sampling devices are presently being used by well logging service companies.

Oil reservoir volume factor: (β): This property is the volumetric expansion of a unit of stock tank oil as a result of gas in solution. Several correlations have appeared in the literature but to the log interpreter the following general rule believed to be due to J. Arps may prove sufficiently accurate in view of the other numerous sources of errors that enter the calculations:

$$\beta = 1.05 + 5 \times (\text{Depth in ft.})\; 10^{-5} \qquad (11)$$

Oil viscosity at reservoir temperature: (μ_o): Again, the following approximate evaluation will prove sufficiently accurate in many respects. First of all, it is necessary to know the expected API gravity of the oil to be produced. This is generally available from neighboring production. The charts of Figure 8 and Figure 9 permit a rapid estimation of oil viscosity in centistokes and of the specific gravity of the oil δ_o at a particular reservoir temperature. The viscosity in centipoise (μ) of the stock tank oil devoid of solution gas and at reservoir temperature is given by:

$$\mu = \frac{\upsilon \text{ centistokes}}{\delta_o} \qquad (12)$$

However, at depth gas is in solution in the oil and its viscosity is considerably reduced; an empirical correlation permits to calculate μ_o at reservoir conditions:

$$\mu_o = \frac{\beta\mu}{1+4\,(\beta-1)\,\mu} \qquad (13)$$

Water viscosity at reservoir temperature: (μ_w): The viscosity of connate water does not appear to be affected materially by salinity variations and it depends mostly on formation temperature. Figure 10 gives this relation.

7. Well Productivity. The fluid flow ratios are to a large extent the controlling factor of the economics of a well's future. The water-oil ratio and water-gas ratio are calculated as follows:

$$\text{WOR} = \beta\ \frac{k_w}{k_{aw}\ (\text{imb})}\ \cdot\ \frac{\mu_o}{\mu_w} \qquad (14)$$

$$\text{WGR} = \alpha\ \frac{k_w}{k_{nw}\ (\text{drain})}\ \cdot\ \frac{\mu_g}{\mu_w} \qquad (15)$$

Another element of well productivity is the expected open hole completion flow potential under stated drawdown conditions:

$$Q_{o_{B/D}} = 3.07\ \frac{K_o h_e}{\beta\mu_o}\ \cdot\ \frac{\Delta P}{\log r_e/r_w} \qquad (16)$$

$$Q_{g_{\text{cu. ft./D}}} = 17.19\ \frac{K_g h_e}{\alpha\mu_g}\ \cdot\ \frac{\Delta P}{\log r_e/r_w} \qquad (17)$$

8. Recoverable Oil and/or Gas. Figure 11 is based on a paper by Doll[3] but the theory has been extended to shaly sands whereas the original paper of Doll applied only to clean sands. In addition, Doll's theory applied only to oil recoverable by water-drive; the recoverable oil (measured at reservoir conditions) being obtained as the difference in oil saturation in the non-invaded and the invaded porous sections. Figure 11 includes the calculations of Doll for recoverable oil by water-drive and also oil recoverable by internal gas drive or by depletion. The recovery figures in the box at the upper right of the chart are on an acre-foot basis. They are a function of the stock-tank oil gravity which is given in API degrees since oil viscosity is related to it. Solution gas, shrinkage, and field pressure should also be factors entering the recovery especially by depletion. However, these factors are not included and the recovery figures should only be used as approximate guides. A remarkable feature of

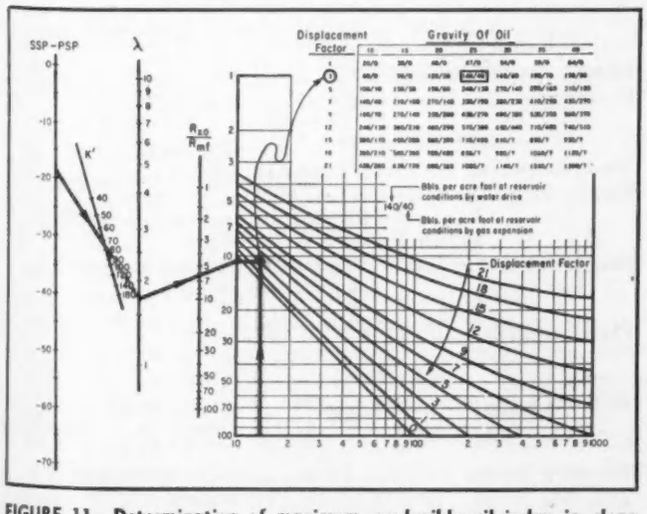
SSP-PSP
λ
Displacement Factor
Gravity Of Oil
Bbls. per acre foot of reservoir conditions by water drive
Bbls. per acre foot of reservoir conditions by gas expansion
Displacement Factor

FIGURE 11—Determination of maximum producible oil index in clean or shaly formations.
Courtesy Schlumberger Well Surveying Corporation

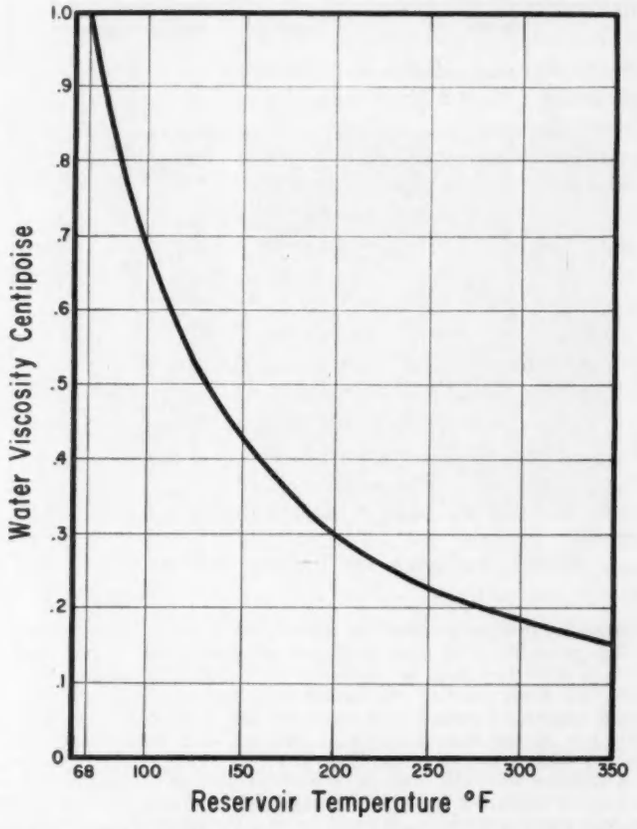

FIGURE 10—Water viscosity as a function of reservoir temperature.

the chart is the absence of porosity as such because it is implicitly included in R_{xo}/R_{mf}.

The quantities needed for computing producible oil per acre x foot and which are all obtainable from the electric log are:

PSP: pseudo-static or actual SP corrected for bed thickness and resistivity.
SSP: static SP obtainable from a clean water sand or by computation, knowing formation water resistivity.
$K' = \frac{Tf}{538} \times 70.7$ where T_f is absolute formation temperature in °R.
λ: need not be read, the intersection on the λ scale only is needed.
R_{xo}: is obtainable from micro resistivity tools.
R_{mf}: is obtainable from the mud resistivity or from direct measurements on mud filtrate.
R_t: is obtainable from resistivity curves after appropriate corrections.
R_{we}: is obtainable from samples of water or from the SSP.

Examples of Log Interpretation in Clean Water-Wet Rocks of Intergranular Porosity

EXAMPLE I

A summary of the interpretation of log of Figure 6 will be given. The formation of interest that extends from 3040 to 3085 feet is the Red Fork sand of N. E. Oklahoma (Pawnee County). Normally, the Red Fork is considered as a shaly sand; however, in this case it behaves as a clean rock because the SP deflection is according to the theory of the electrochemical potential. Formation water is known to have a resistivity of 0.057 ohm-meter at 78° F. or 0.04 ohm-meter at 108° (BHT). Using a K value of $70.7 \times \frac{568}{538}$ and a mud filtrate resistivity of 1.10 ohm-meter, one finds $R_{we} = 0.038$ at 108° F. which is a very good check indeed with the known resistivity of the formation water. In addition, the sand may be considered as water-wet in view of the resistivity gradient exhibited on all three curves. The fact that the gradient is observable on all these curves indicates that the invasion is rather shallow. It is normal that it should be so

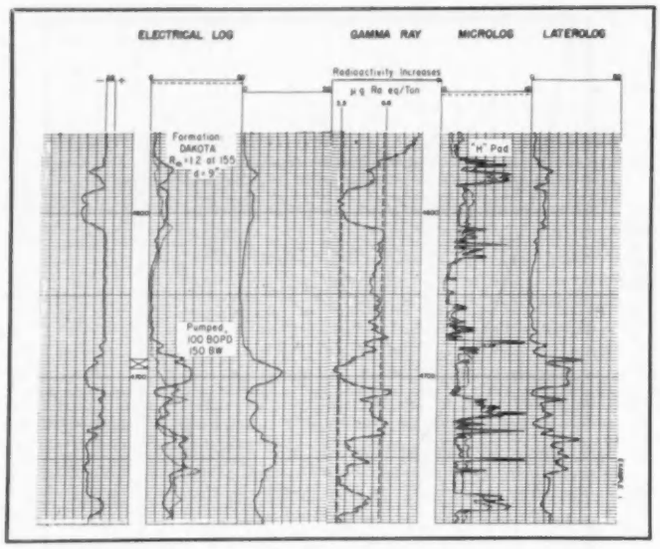

FIGURE 12—Example Log 2—Denver-Julesburg Basin.

because logging operations took place shortly after the sand was drilled through. The plateau shown on the lateral curve from 3040 to 3054 feet does not indicate that irreducible water saturation has been reached but rather that the resistivity gradient should continue upward if it were not for the decay zone characteristic of the lateral curve at the top of a resistive bed in contact with a bed of lesser resistivity.

A definite water-oil contact or zone of 100 percent water saturation is indicated at 3063 feet and R_o, the resistivity at 100 percent water saturation, is read to be 2.0 ohm-meters.

Effective pay, however, does not extend to 3063 feet but rather to the level at which no water should be produced if the well were to be selectively completed to that level. This level will be established by relative permeability considerations. No microlog was run in this well, therefore, effective pay must be evaluated from the SP curve and the short normal, and from considerations of potential water production as made above. Judging from the SP and short normal curves, there are no major shale breaks in the sand and it may be considered as homogeneous.

Porosity may be ascertained in two ways: (a) from the R_o value when the latter is corrected for bore hole effects: R_o = 1.5 ohm-meters. Hence the formation factor is $F = 1.5/0.038 = 39.5$. Using Humble's formula for the relation between formation factor and porosity, we find $\phi = 14.5$ percent. (b) from the short normal curve that reads 11 ohm-meters in the water zone, and using Figure 2, we have $\frac{R_{am}}{R_m} = 11/1.4 = 7.9$. Using SP = —108 mV, d/AM = 2 and a residual oil saturation of 15 percent, we find 14 percent porosity. This checks satisfactorily with the previous determination. Final values are: ϕ = 14.5 percent; F = 39.5.

Saturation in formation water is obviously not a constant but it decreases upward from 100 percent at 3063 feet. The simplest way to obtain saturation in this log is by Archie's law, Equation (1). Applying it at various levels and after correction of the lateral curve readings for bore hole effects, the following values are obtained:

TABLE 1

DEPTH	R_t Corrected	S_{we}
3046	18	29%
3050	16	31.5
3055	13	34.0
3060	10	39.0
3065	6.5	48.0
3070	3.0	71.0
3074	1.5	100.0

Specific permeability may be determined in various manners:

(a) from the tortuosity correlation, Figure 4, $t^2 = F \times \phi = 39.5 \times 0.145 = 5.7$ and using the average correlation curve, K = 7 md.

(b) from the chart of Figure 5 and if it is assumed that the irreducible water saturation is 29 percent (that observed at the top of the sand) one obtains K = 8 md.

(c) from the Schlumberger Chart E 4 using similar figures, one obtains K = 8 md.

(d) from the Schlumberger Chart E 2 which makes use of the resistivity gradient, we have: basic resistivity gradient = $\frac{1}{1.5} \cdot \frac{18 - 6.5}{19} = 0.4$. API gravity of stock tank oil is 36° and water salinity is about 150,000 ppm. K = 250 md. This result is at considerable variance with the previous three and will be discarded. Calculations by Formula (6) give K = 14 md. Formation permeability will be taken as 8 md in future calculations.

Relative permeabilities are determined by equations (7), (9) and (10) since this sand will produce a water-cut by imbibition of water into the oil sand. Equation (10) may not be used to calculate the residual oil saturation since there is no microlog available. S_{wt} is assumed = 15 percent. Based on the previously established water saturation, the following values are obtained for the relative permeabilities:

TABLE 2

DEPTH	k Water	k Oil	WOR
3046	0	.72	0
3050	0	.66	0
3055	.01	.61	.07
3060	.02	.50	.18
3065	.065	.37	.25
3070	.20	.07	13.0
3074	1.00	0.00	infinite

Fluid properties: For a depth of 3050 feet, a reasonable value for the oil reservoir volume factor is obtained from equation 11 which gives $\beta = 1.20$.

From Figure 8, kinematic viscosity of 36 API crude at 108° F. is 4 centistokes. From Figure 9, specific gravity at 60° F. is 0.85 and 0.83 at 108° F. Hence, oil viscosity at 108° is 3.35 cps. From Figure 10, water viscosity is 0.62 cps at 108° F.

Water oil ratio and well productivity have been calculated from equation 14 and are recorded in Table 2. The estimated reservoir pressure is $3050 \times 0.434 \times 1.10 = 1450$ psi.

Assuming a drawdown of 500 psi and an effective pay of 2 feet, the expected open hole completion oil production rate is obtained from Equation (16) and it predicts 0.63 bpd. In fact, the well would not have made a commercial producer had it not been for fracture treatment in the interval 3041 — 50 feet through 18 perforations after which the well made 35 bpd natural. Recovery per acre foot of pay may not be calculated because a micro-tool log is not available.

EXAMPLE II

The log in Figure 12 is from the Dakota section in the Denver-Julesburg basin. The D sand is at 4586 feet-4606 feet and the J sand at 4686 feet-4706 feet. The J sand is the section of interest. While the Dakota sands generally behave as shaly, in this particular log it is believed that clays have been removed during the process of deposition. This is confirmed by calculations of the static SP deflection from known water salinity and mud filtrate resistivity, the result being —48mV, whereas, the actual SP is —45mV. Formation water resistivity in place is 0.25 ohm-meter. The summary of the J sand interpretation according to the preceding outline of a comprehensive interpretation procedure, is as follows:

Effective pay thickness: 20 ft.

Porosity: by microlog: empirical, Chart C_2: 25%
by Chart C_{10} : 26% F = 11.
by short normal: 23%

Water saturation: by Archie's formula: 45%

Permeability: by tortuosity correlation: 500 md
Formula 6 may not be used because R_{t1} is unknown. Probable K = 100 md

Relative Permeability: $S_{w1} = 7\%$ $S_{wm} = 41\%$ $S_{ot} = 20\%$
$k_w = 0.065$
$k_o = 0.140$

Fluid properties: $\beta = 1.285$ API = 38°
$\mu_o = .675$
$\mu_w = .42$

Well Productivity: WOR = 0.58 Actual WOR = 1.5
Q_o = 415 B/D Actual Q_o = 100 B/D
(on K = 100 md) ΔP = 500 psi

Recovery Barrels per Acre Foot: by water drive: 900 bbls
by depletion: ?

EDITOR'S NOTE: Parts II and III will appear in coming issues of WORLD OIL. A complete Nomenclature listing and all references cited will appear with the third part of this series.

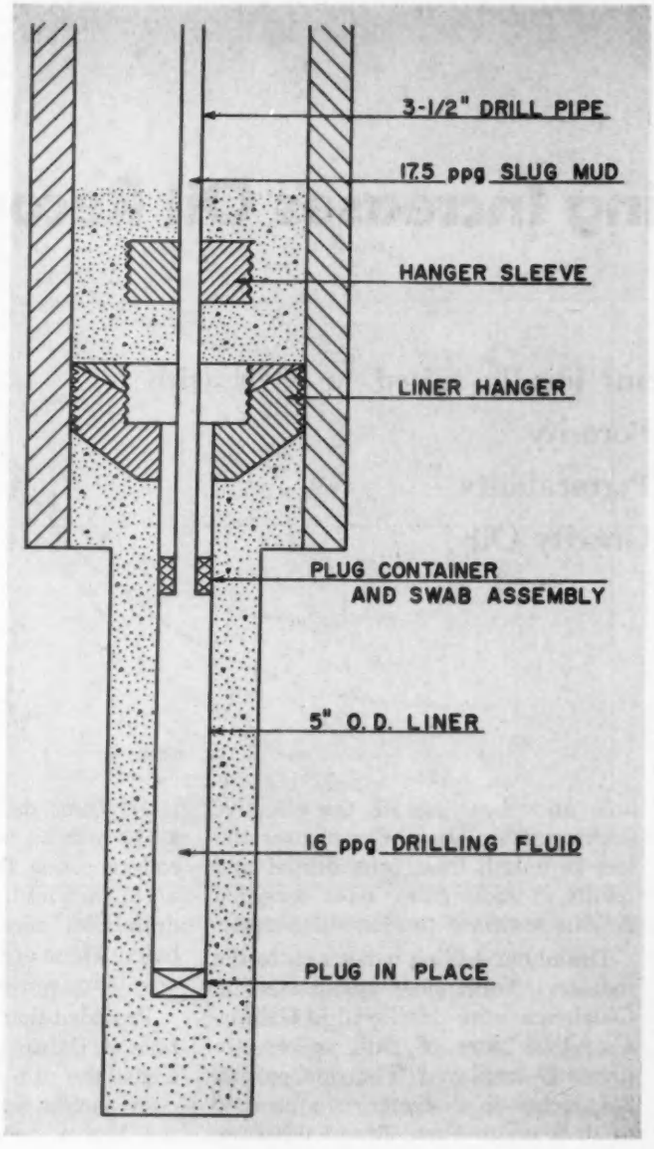

FIGURE 1—The liner plug is in place and the drill pipe ready to pull. Heavier mud in drill pipe will displace excess cement upward, leaving the liner top clean.

Mud Slug Cuts Liner Cost

Heavy 17.5 pound per gallon mud displaces cement above the top of liner without effecting the splice and can be drilled without damaging top of liner.

By J. J. FOWLER
Independent Oil Producers
McAllen, Texas

THE USE OF A SLUG of heavy drilling mud in the drill pipe before the plug bumps can save an operator $6000 per well when setting a liner. The following method has been used very satisfactorily in the Tabasco Field of Hidalgo County, Texas.

When field wells are drilled, a 10¾-inch surface pipe is set at 1100 feet in a 15-inch hole, and 7⅝-inch pipe is landed at 7300 feet in a 9⅞-inch hole. The 6⅝-inch hole is drilled to 8700 feet using mud weighing 16 pounds per gallon and a 5-inch flush joint liner is set.

A packer is not used to seal the two strings. This eliminates perforating to test the liner splice. Dual completions, producing from formations behind both the 7⅝-inch casing and the 5-inch liner, require a secure splice.

Ordinarily excess cement above the splice was reversed out. Although good circulation was indicated on the surface, apparently enough cement was forced back into the formations to void the splicing area of cement. Some 6½ barrels were needed on a 300 foot overlap of the 5-inch and 7⅝-inch casings.

Pressure tests of the splice with a squeeze tool set above the liner showed leakage and numerous squeezes were necessary to effect a seal. Fortunately, no trouble was encountered in obtaining a good cement job on the liner itself.

Here is how a good splice can be had economically. The liner is run to bottom, spaced out and then hung. The set tool is left engaged while circulating to condition the mud and the hole. When ready to cement, the swab-cup assembly is freed from the liner hanger but is left engaged to the liner. After the cement is mixed and pumped and the drill pipe wiper plug is released, the drilling mud is measured as it is pumped down the drill pipe.

As the wiper plug nears the swab, the pumps are slowed to below 500 psi. An increase to some 1100 psi signifies that the shear pin in the liner setting tool has been ruptured and the liner wiper plug has released. A prepared system of slug mud weighing 17.5 ppg is then measured into the drill pipe.

When the liner wiping plug reaches bottom, the drill pipe should contain enough of the heavier mud to pull dry, as shown in Figure 1. Surface cementing equipment is disengaged and drill pipe pulled from the hole.

Excess cement has been displaced 150 feet above the liner top. After drilling out the cement the splice is tested to 5000 psi for 30 minutes. Parallel tubing strings are used to dually complete and upper perforations have been treated with pressures to 6300 psi.

An extra cementing truck was used to mix and pump the slug mud. A calibrated tank could easily replace the extra truck. The liner volume of 30 barrels proves an excellent slug for the drill pipe volume of 50 barrels.

Of six wells drilled in the Tabasco Field, the first four involved an additional three days time over the last two to obtain a splice. The so-called slug method used on the last two completions saved $6000 per well. **—The End**

Drainhole Drilling Increases Oil Recovery

This method seems ideally suited to wells with

- **Low Porosity**
- **Low Permeability**
- **Low Gravity Oil**

By MYRON BUTTRAM,
Hi-Angle Drilling Company
Oklahoma City

THE INTRODUCTION of drainhole drilling into Oklahoma is comparatively recent. Because of the characteristics of the multiple pays found in many oil fields throughout the state, the application of drainhole drilling is helping to solve many drilling problems and is increasing production especially from marginal wells.

Drainhole drilling is a method of actually penetrating the formation away from the well bore and is closely controlled as to direction from the well bore and the angle of deflection. This method is used to open up low permeability formations with a bore hole and thus increase the effective drainage area. Drainholes of over 150 feet in length have been drilled and results in most cases, have shown a definite sustained production increase.

Drainhole drilling is not new to the industry. Tools now being used in Oklahoma were developed in California. Two sizes of drill collars are presently employed. The smaller size, 3⅜ inches in diameter, can be used to drill up to three drainholes from one level when working inside a 5-inch casing or well bore. With the larger, 4⅜-inch diameter, drill collars it is possible to drill inside 6⅝-inch or larger cased or uncased hole. Usually a 3¾-inch bit is used with the smaller collars, while the larger collars take a 4¾-inch mill or bit. Up to 6¾-inch drainholes may be drilled in larger holes. These are the largest drainholes now being drilled.

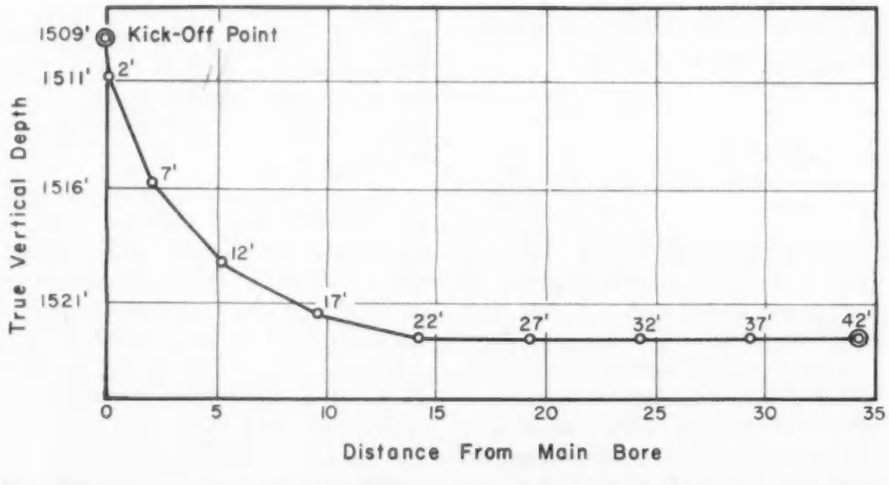

FIGURE 1—A plot of the drainhole inclination. This drawing gives a picture of the actual distance the drainhole is from the original well bore. It also plots the actual vertical depth of the drainhole.

Provided there is oil in place, drainhole drilling should definitely increase the rate of production. Lifting costs should be decreased because of the higher production. Because this type of completion increases the radius of drainage it will result in an increase in per acre recovery as compared to other methods that do not penetrate very far beyond the well bore.

It is preferable to circulate oil while drilling to keep formation contamination to a minimum. In many cases it is possible to use lease oil for drilling. In other cases, where it is difficult to break circulation, where the formation will break down under the hydrostatic head of the circulating fluid, or where a formation is on a vacuum, air has been used successfully.

Where the well to be completed with drainholes has casing set, formation waters present no problems. Circulating fluids and methods would depend on whether or not the formation is cased and on the particular wells characteristics.

Drainhole drilling has been used with some degree of success in the

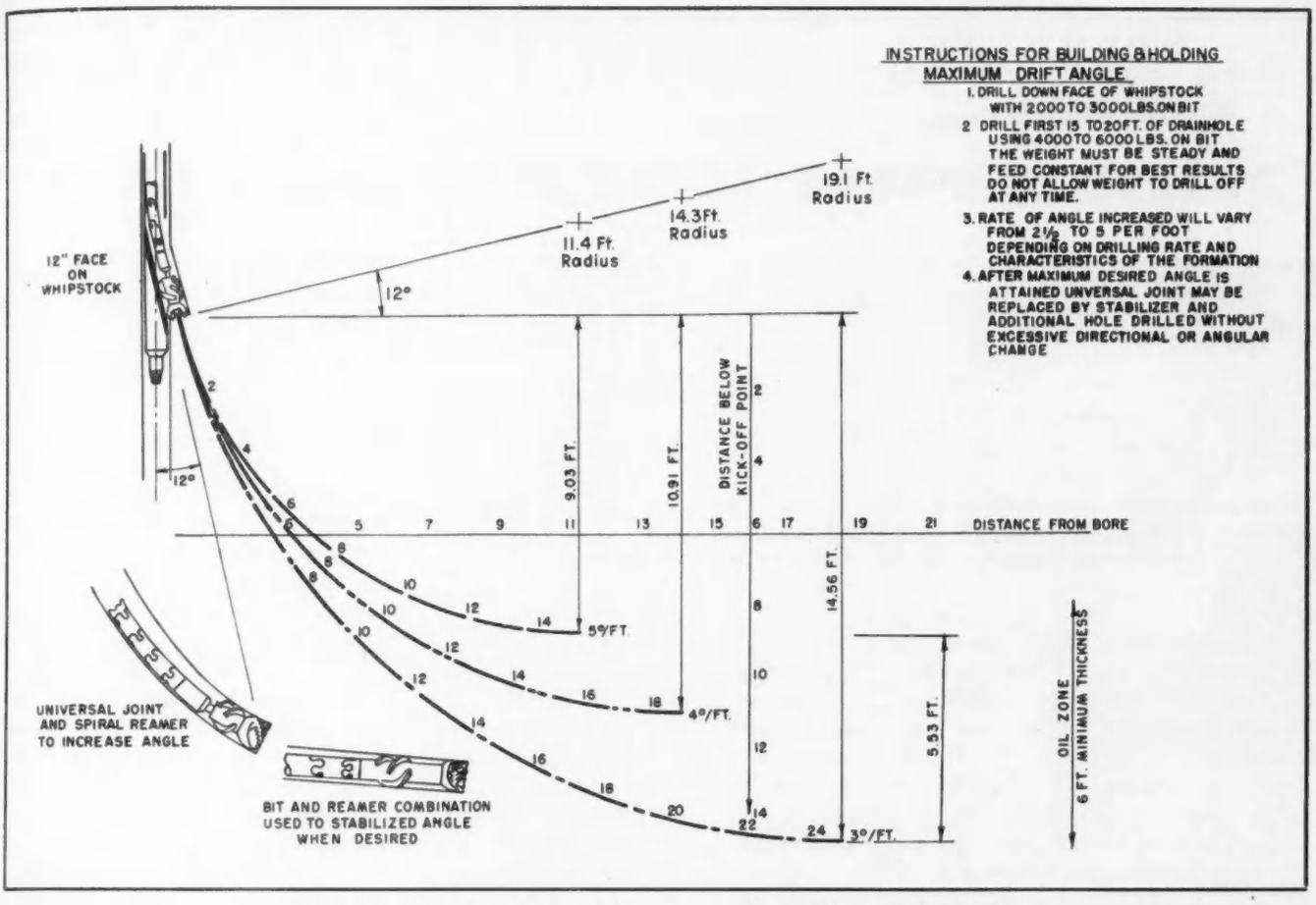
INSTRUCTIONS FOR BUILDING & HOLDING MAXIMUM DRIFT ANGLE
1. DRILL DOWN FACE OF WHIPSTOCK WITH 2000 TO 3000 LBS. ON BIT
2. DRILL FIRST 15 TO 20 FT. OF DRAINHOLE USING 4000 TO 6000 LBS. ON BIT THE WEIGHT MUST BE STEADY AND FEED CONSTANT FOR BEST RESULTS DO NOT ALLOW WEIGHT TO DRILL OFF AT ANY TIME.
3. RATE OF ANGLE INCREASED WILL VARY FROM 2½ TO 5 PER FOOT DEPENDING ON DRILLING RATE AND CHARACTERISTICS OF THE FORMATION
4. AFTER MAXIMUM DESIRED ANGLE IS ATTAINED UNIVERSAL JOINT MAY BE REPLACED BY STABILIZER AND ADDITIONAL HOLE DRILLED WITHOUT EXCESSIVE DIRECTIONAL OR ANGULAR CHANGE
12" FACE ON WHIPSTOCK
11.4 Ft. Radius
14.3 Ft. Radius
19.1 Ft. Radius
12°
9.03 FT.
10.91 FT.
DISTANCE BELOW KICK-OFF POINT
14.56 FT.
5.53 FT.
DISTANCE FROM BORE
5°/FT.
4°/FT.
3°/FT.
OIL ZONE
6 FT. MINIMUM THICKNESS
UNIVERSAL JOINT AND SPIRAL REAMER TO INCREASE ANGLE
BIT AND REAMER COMBINATION USED TO STABILIZED ANGLE WHEN DESIRED

FIGURE 2—A drawing and plot of the actual mechanics of drilling a drainhole.

following types of operations:

- New wells
- Remedial wells
- Recompletions
- Bypass plugged or caked formation face
- Water input and salt water disposal wells

The ideal reservoir conditions for effective use of drainhole drilling may be cited as:

- Low permeability
- Low reservoir pressure
- Low gravity oil

This method is also adaptable to exposing more formation prior to fracturing operations.

Limitations of Use. Drainhole drilling is not a cure-all, nor is it applicable in every situation. Where a well is making a substantial amount of formation water, increasing the permeability could increase the water production to a point where further operations would not be economical. Wells with thin pay sections offer poor prospects for successful drainhole drilling.

However, a recent well, drilled to 967 feet with cable tools with 5½-inch casing set on top of the pay zone, drilled into a 7-foot pay interval with six drainholes. Three drainholes, 8 feet in length, were drilled just under the pipe. Three more holes were drilled 18 inches lower. Oil was used to circulate cuttings. It took 3100 pounds per square inch pressure to break down the formation before fracturing, then the well was fractured at approximately 1700 psi. The first six days the well produced 70 barrels of oil per day. Production was then reduced to prevent pulling the well too hard. The six drainholes were 3¾ inches in diameter and totaled 39 feet in length. Thus, the drainholes increased the bore area by four times the amount of the normal vertical well bore.

Some 35 wells had previously been drilled in this field and completed by sand fracturing. In these wells the formation usually broke down at from 5500 to 5800 psi and then fraced at approximately 3000 psi. Initial production for these wells averaged 15 to 20 barrels of oil per day.

Economics of Drainhole Drilling. **Production Problems:** From the completion of the first oil well, one of the basic concerns of the oil industry has been the determination of the amount of recoverable hydrocarbons from the known reserves. The all-important depletion curve is directly affected by such factors as poor completion practices, formation blocks, water encroachment, etc. Low formation pressures and low permeabilities are formation characteristics that also lower the percent recovery.

Corrective Measures: Corrective measures have been established to counteract these problems to some extent, and have contributed greatly toward the solution of the problem. Such measures include the use of oil base or oil emulsion mud, lease oil, and gas or air as circulation fluid while drilling into or through possible pay formations. Good results have been obtained from corrective measures such as acidizing, hydrofacing, sandfracing, etc. for increasing porosity and permeability and also for penetrating areas of filtration damage.

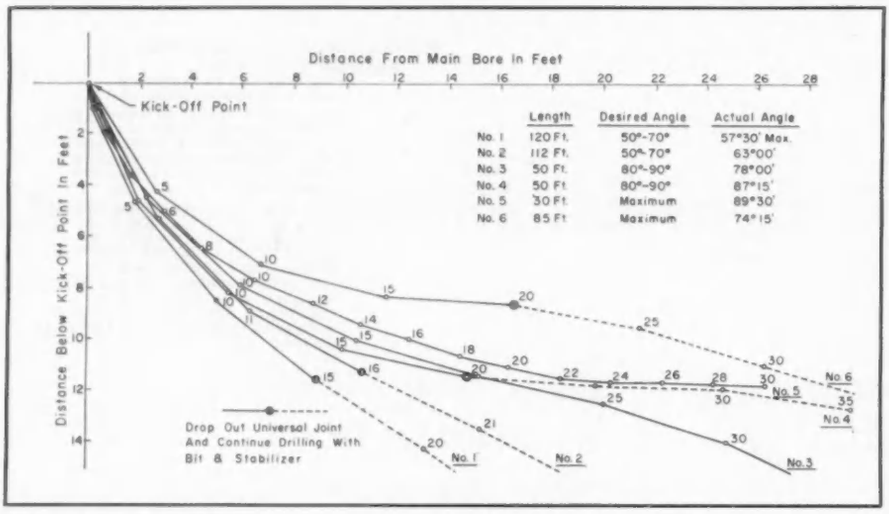
Distance From Main Bore In Feet
Kick-Off Point
Distance Below Kick-Off Point In Feet
Length
Desired Angle
Actual Angle
No. 1 120 Ft. 50°-70° 57°30' Max.
No. 2 112 Ft. 50°-70° 63°00'
No. 3 50 Ft. 80°-90° 78°00'
No. 4 50 Ft. 80°-90° 87°15'
No. 5 30 Ft. Maximum 89°30'
No. 6 85 Ft. Maximum 74°15'
Drop Out Universal Joint And Continue Drilling With Bit & Stabilizer
No. 1
No. 2
No. 3
No. 4
No. 5
No. 6

FIGURE 3—A plot of deviation surveys taken in drainhole wells. Note actual length of drainholes as compared to actual vertical depth and depth from main well bore.

Practical Tools: In Oklahoma, a combination of tools are being used to adequately drill single or multiple drainhole from the vertical bore anywhere from 6 degrees to 90 degrees from the vertical. This drilling is being done in open, lined, or cased holes. The holes start at the top of the production zone, are oriented as to their required direction and drilled with reasonable control to ordinarily sufficient lengths. These new production holes may be surveyed, logged, and cased if necessary.

As stated before, results from drainhole drilling have shown, in most cases, a definite increase in production. However, sometimes where the drainhole drilling operations are successful, mechanically, the net results may not be economically successful. A well recently drainholed in Oklahoma in a formation with thin sand laminations, estimated at ⅔ shale and ⅓ sand, had three 50-foot and one 42-foot drainholes drilled. Drainholing this well resulted in a settled production increase from its original 1 barrel of oil per day to 4 barrels of oil per day, an increase of 300 percent.

This is not commercial production although if the well holds up it should pay the cost of rework. If the well had been a 3- or 4-barrel well and the same percent increase had been obtained in redrilling with drainholes, the operation would certainly have been commercial. These results might be attributed to the formation characteristics and hydrocarbon content and do not reflect unfavorably on the drainhole process.

In the majority of wells, producing from tight, hard formations, the production decreases rather rapidly after initial production. While the proration of well allowables are a source of contention in the industry, of the 65,000 wells in Oklahoma, over 85 percent are not curtailed in their production. Recent reduction in the allowable of 20 percent on a per well basis should have lowered the allowable for the state by 112,600 barrels. The actual reduction was less than 20,000 barrels which bears out the statement that the greater percent of the wells in the state will not produce the maximum allowable granted. Under these conditions the application of drainhole drilling will greatly assist producers in Oklahoma.

In wells already drilled the initial investment has already taken place. In the majority of cases, it is possible to evaluate formation conditions and determine whether there is a sufficient amount of oil in place, to make reworking operations with drainholes economic. For a small percentage of the original investment the chance of increasing production and obtaining a higher percentage of the reserves is worthwhile.

There are many leases that are near the economic limit of operations. It should be profitable to evaluate the lease in light of recent developments and determine whether the lease should be operated or abandoned. In many cases one or more wells are being produced uneconomically in order to hold a lease for possible secondary recovery operations or for deeper possibilities which may exist.

In many shallow areas in Oklahoma there are wells which come in with an initial production of from one-half to one barrel per day and are therefore considered non-commercial. In some instances where drainhole drilling has been applied these wells have increased to approximately seven barrels per day by the drilling of six 50-foot drainholes. Then after fracing the drainholed well, the production has increased to as high as 100 barrels per day, settling down to approximately 50 barrels per day within 30 days. During the next 60 to 90 days the wells declined to approximately 30 barrels per day and have shown little decline to date. This is in comparison to wells which have been fraced, only, and made 40 to 60 barrels initially and then after 30 days are down to one to 12 barrels per day.

While neither the drainholing technique nor any of the other well stimulating methods known today are the answer to high percentage recovery, where properly applied, under favorable circumstances, they are enabling operators to recover ever increasing percentages of the known reserves.

—The End

About the Author

MYRON BUTTRAM, president of Hi-Angle Drilling Company, Oklahoma City, graduated from the University of Oklahoma in 1936. Since that time he has been associated with Buttram Petroleum Company in development, land and production work in many states including Louisiana, Texas, Colorado, Wyoming and California. While operating in Wyoming he became interested in drainhole drilling equipment and techniques.

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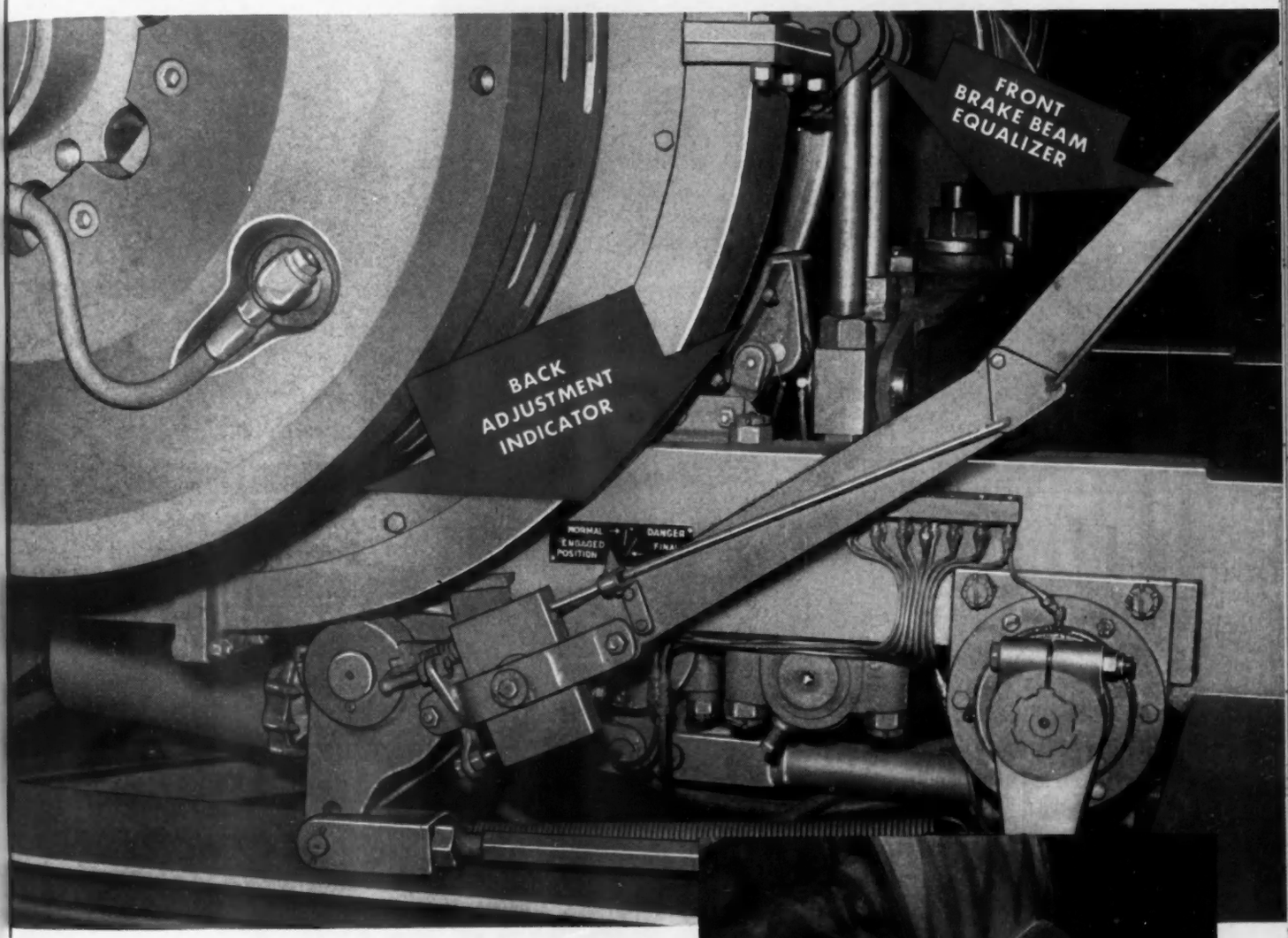

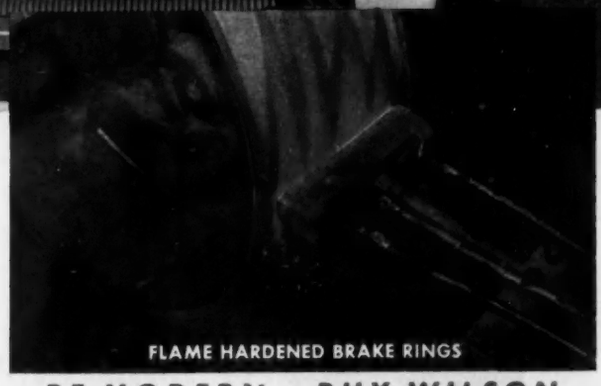

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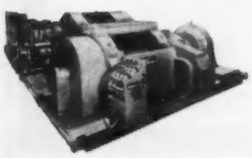

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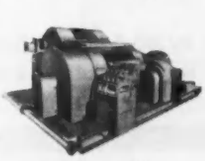

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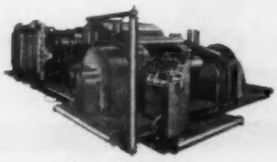

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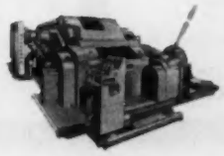

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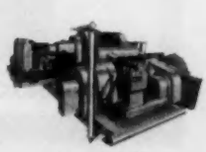

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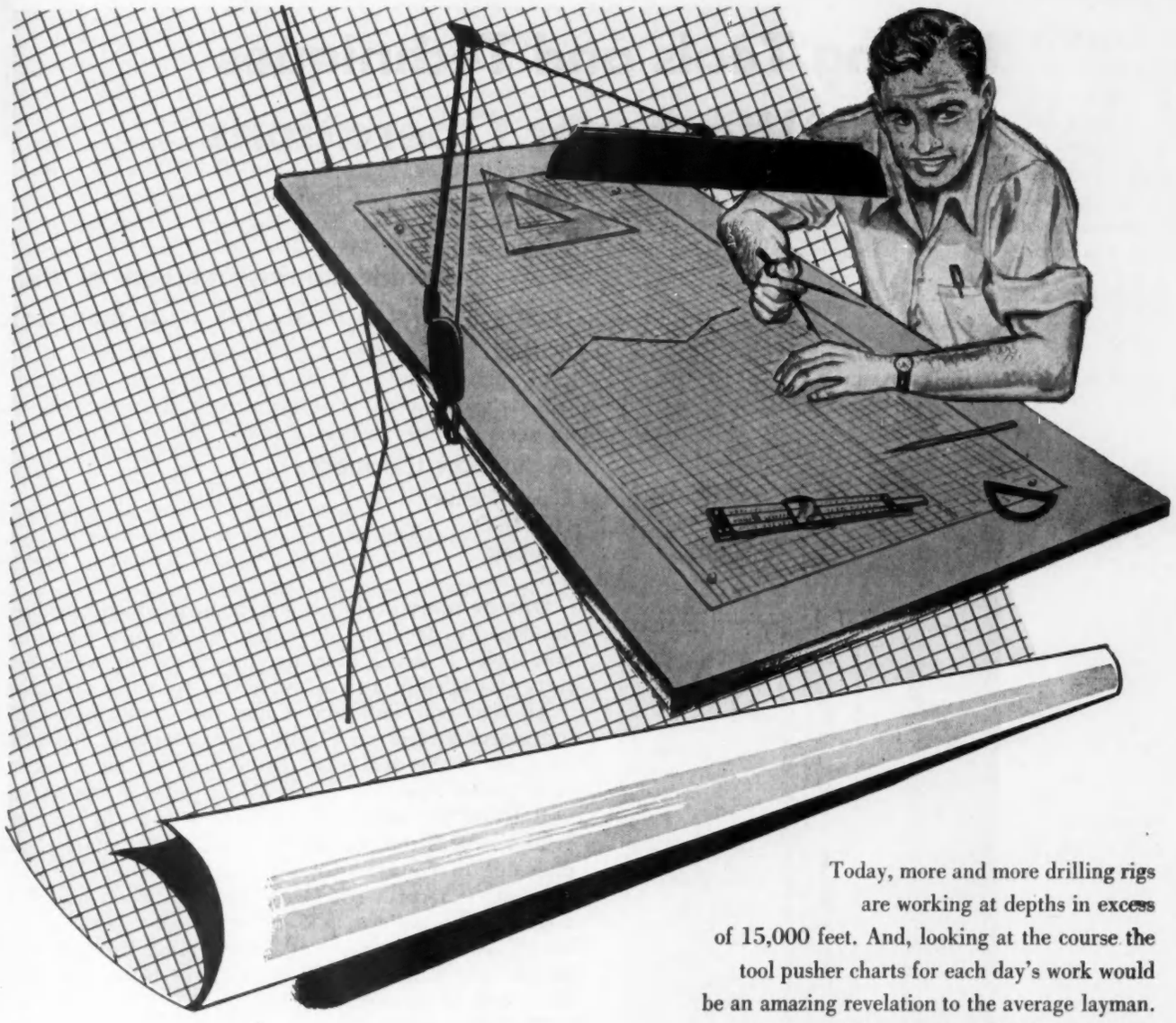

Charting His Course

3 MILES DOWN!

Today, more and more drilling rigs are working at depths in excess of 15,000 feet. And, looking at the course the tool pusher charts for each day's work would be an amazing revelation to the average layman. To him, drilling an oil well "off vertical" is absolutely incredible . . . the fact that a string of drill pipe will rotate at high speeds while in an angular position seems impossible. To the tool pusher, however, in charting the drilling operation, all it takes is the "know how" and the *right equipment.* Rock Bits, for instance, built of tough, high strength material that will endure the torque and weight of today's deeper oil well drilling

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Fishing Tools and Techniques
Part 3-Washover Operations

An old standby method of 'fish' recovery is still used, but with new tools added.

By WELDON L. MEDDERS
Chief Engineer
HOMCO
Houston

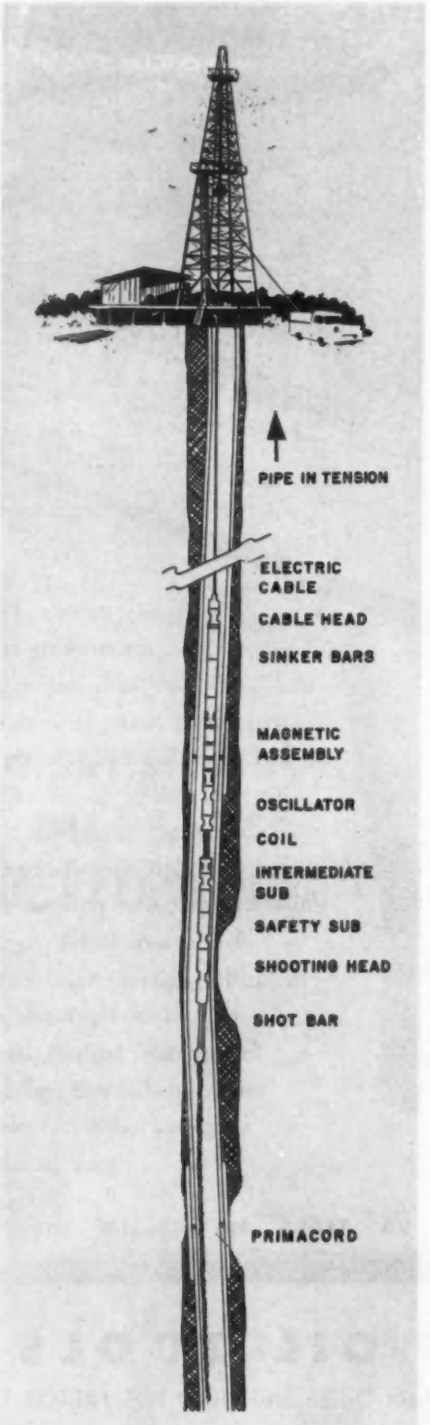

FIGURE 23—Combination free-point indicator and string shot. By combining these two services into one tool, a trip can be saved.

ONE OF MANY new tools and methods which have been developed to facilitate the extraction of stuck pipe from bore holes is string shooting. Basically, this is the first successful attempt at wireline fishing for stuck drill pipe.

An electronic indicator is first run in the hole. This instrument records on a graph any changes in molecular structure of the drill pipe, drill collars, tubing or casing. As it moves downhole it records all joints in the pipe as well as gas lift valves and ruptures or splits in the pipe. It also records the changes in molecular structure of the pipe due to the application of torque, tension, or compression. It records stretch in the pipe when tension is taken at the surface, and by repeatedly checking this stretch as the instrument moves downhole the free point of the pipe is determined; since, at or below this point there will be no stretch in the pipe.

The electronic indicator is then brought out of the hole and a string shot consisting of a 15-foot long charge of primacord is run in the hole. Left hand torque is applied to the pipe and the charge is fired at the stuck point. The percussion of the shot is sufficient to loosen the threaded connection and the upper "free portion" of the pipe spins off and is brought out of the hole. No damage results to the pipe or joint where the shot was fired.

With this more or less conventional procedure, it is necessary to make two trips with the wireline to effect recovery. These two services are now combined into one package. One wireline trip makes a combination free-point indicator and backoff run. Figure 23. This effects a savings of from one to two hours in time, depending on the depth of the run.

After bringing the upper free portion of the pipe out of the hole it is then necessary to remove the stuck portion which remains. This is known as an "outside" job and by comparison, the removal of the upper free portion was simple. Here it is sometimes necessary to combine science with intuition and plain fisherman's luck.

Generally, the conventional approach is to make up a string of washpipe on the end of which is placed a rotary shoe or milling head. This washpipe, of sufficient diameter to go over the stuck fish, is then lowered into the hole, pumps are turned up to capacity, and the washover oper-

ation is begun. The rotary shoe drills around the stuck pipe and the "fish" is swallowed up into the washpipe, freeing it from the formation. After freeing from 300 to 600 feet, the washpipe is pulled and the drill pipe is run in and either screwed into the top of the fish or secured to the fish with an overshot. A string shot is then run in on a wireline and fired at the point where the rotary shoe has previously washed. If the portion of the fish previously freed by the washover operation has not re-stuck while all these subsequent operations were taking place the fish can be retrieved. If it has stuck again it will be necessary to repeat the washover operation.

To eliminate the need of all these separate efforts, the washover operation and the subsequent drill pipe run to secure the fish have recently been combined into a single operation. A tool known as a washover-backoff connector, Figure 24 combines all the above operations into one. Thus, it eliminates the possibility of the fish re-sticking and also eliminates an extra trip.

A typical operation for a washover-backoff tool illustrated in Figure 25 is as follows:

- The desired length of washpipe is made up with the washover shoe on the bottom.
- The lower part of the washover-backoff tool is screwed into the washpipe.
- The drill pipe is made up into the top tool connection, and
- The tool is run-in.

The washpipe first washes over and frees the fish. As the washpipe approaches its limit lengthwise, the inner stem of the tool with a threaded pin, presents itself to the threaded box of the fish looking up. When this pin and box meet, weight is applied and an over-riding clutch in the upper part of the tool, affixed to the drill pipe, engages with a mating clutch on the inner stem which is normally a free floating member in the tool. Right hand rotation is continued and the threaded end of the tool is made up lightly into the fish. The string is then picked up and the resulting tension causes two powerful and positive clutches to engage within the tool. Right hand torque of considerable proportion is then applied and the threaded portion of the tool is made up very tightly into the fish. The clutches are then disengaged by slacking off to a neutral point so that neither the positive nor the over-riding clutch are in proximity. The washpipe is then rotated freely and independently of the inner part of the tool while the string shot is being run down on a wireline. When the shot reaches the proper depth, tension is again applied, the two positive clutches engage, and left hand torque is applied to the string. The shot is fired and the fish spins loose. The string is then pulled only to the point where the upper end of the fish is at the rig floor. With the washpipe hanging in the slips the fish is then stripped out of the pipe. The tool is then screwed back on the washpipe and the operation is repeated.

The origin of the washover-backoff connector is to be found in early backoff tools known as "expanding taps," Figures 26A, B and C, which made their appearance back in the days of cast iron casing and manila cable.

This tool was in common usage as early as 1915. A modern version, Figure 27, is still in use in today's fishing strings. This expanding tap in its original form, consisted of a threaded expandable pin for engaging the fish, and a mandrel which was slidably mounted in the sleeve or body of the tool. The lower face of the sleeve had a clutch which, when weight was applied, engaged a similar clutch on the mandrel for transmitting torque to the lower threaded connection. In the final analysis, about the only difference between these two tools lies in the fact that the expanding tap was not run in conjunction with washover pipe. When running an expanding tap, there was no sure way of knowing at what depth a backoff would be made, therefore, the correct length of wash-

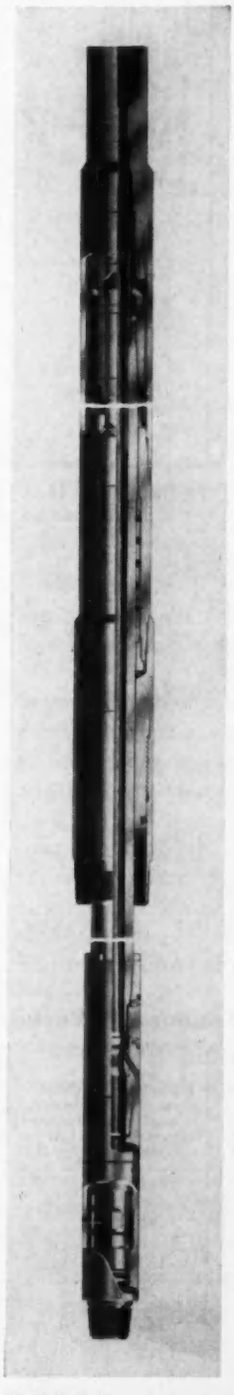

FIGURE 24—A washover-backoff tool with a pin down for recovery of drill pipe with the box end up. This tool combines washover and recovery operations in a single run.

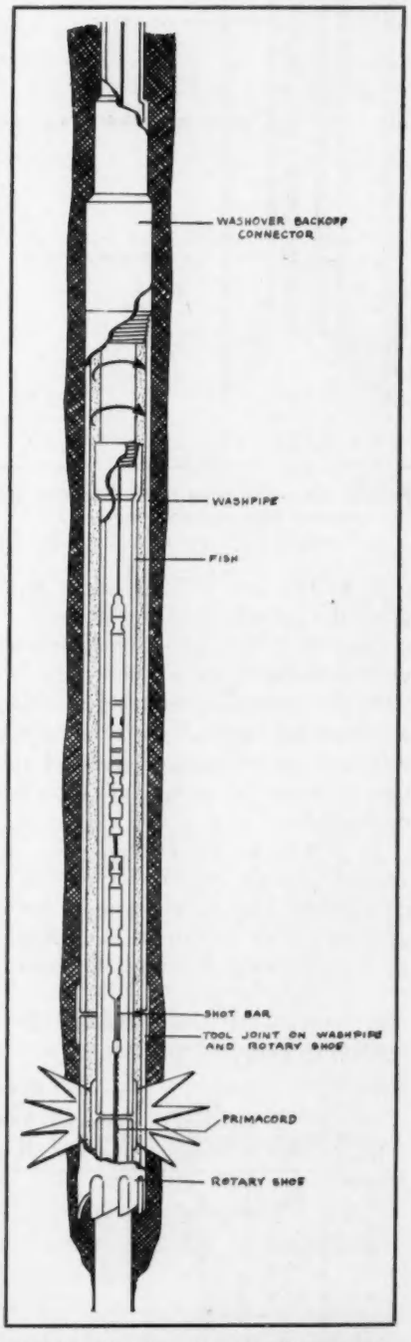

FIGURE 25—This drawing illustrates a complete washover-backoff operation. The rotary shoe washes over the stuck drill pipe until an amount equal to the length of the washpipe has been freed. The pin of the connector tool engages the box of the fish. The free point indicator determines the lowest point where the fish is stuck and with left hand torque applied to the drill string, the string shot is set off opposite a tool joint and that portion of the fish is recovered.

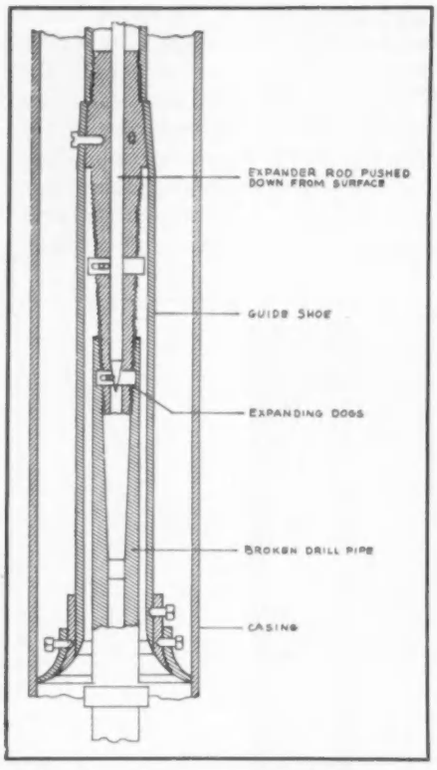

FIGURE 26a—A drawing of the Schildwachter extractor that was patented in 1915.

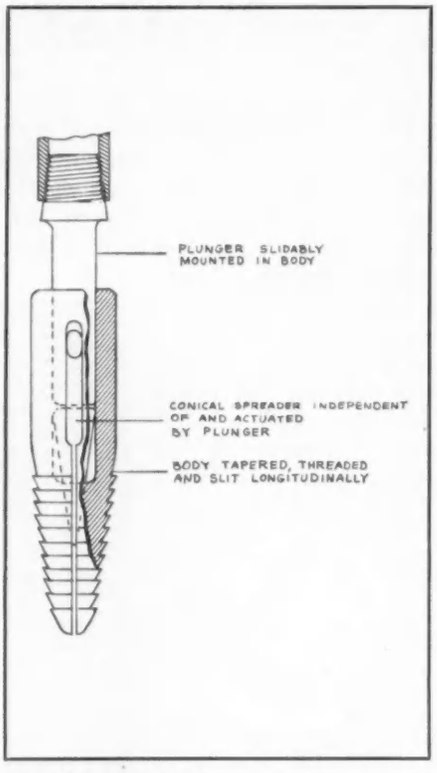
PLUNGER SLIDABLY MOUNTED IN BODY
CONICAL SPREADER INDEPENDENT OF AND ACTUATED BY PLUNGER
BODY TAPERED, THREADED AND SLIT LONGITUDINALLY

FIGURE 26b—The Sorensen fishing tap of 1922 had no means of release.

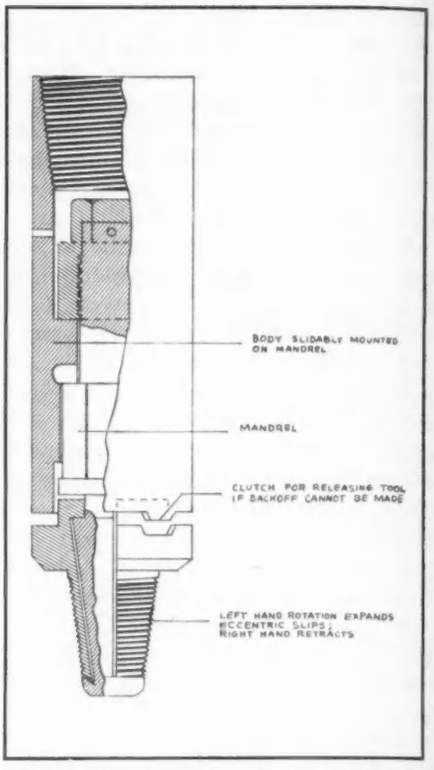
BODY SLIDABLY MOUNTED ON MANDREL
MANDREL
CLUTCH FOR RELEASING TOOL IF BACKOFF CANNOT BE MADE
LEFT HAND ROTATION EXPANDS ECCENTRIC SLIPS; RIGHT HAND RETRACTS

FIGURE 26c—Backoff tool of 1929 by I. Thomas combines rugged construction with means of releasing tools.

pipe to run was difficult to determine. It was not until after the advent of string shooting, with its pinpoint accuracy, that the feasibility of combining a backoff tool with washover pipe arose.

In the continuing fight against time this tool has proved a real time saver. Time and again its worth has been reflected in the cost per foot of recovered pipe. This is the criterion by which all tools and methods must be evaluated.

In a well in the Houma, La., area drilling had proceeded without eventuality to 9980 feet. Suddenly a lost circulation zone developed allowing sandy shale, lime and anhydrite to slough in around the 4½-inch X-hole drill pipe string, sticking it in open hole from just under the surface pipe at 1852, all the way to the bottom. A freepoint indicator was run and the free pipe was backed off at 1811 feet; 41 feet up in the 10¾-inch casing. A total of 17 backoffs was made in 207 actual running hours with a 7 washover-backoff connector, resulting in the recovery of 9188 feet of pipe at a cost of $1.68 per foot.

A resume of this job is given in Table 5. The average running time of 10.9 hours to recover 541 feet of pipe could hardly be approximated by any other method. Part of this speed, of course, must be attributed to the use of an interspersed carbide rotary show. By using this type shoe from 3383 feet to the bottom of the hole (a total of 5805 feet) it was not necessary to pull the washpipe

TABLE 5—Resume of Washover Backoff Job in Houma Area

Backoff No.	Depth, Feet	Time Going in Hole, Hours	Washover Time, Hours	Circulation Time, if Any Hours	Time to Run Shot and Indicator, Hours	Time Coming Out of Hole, Hours	Total Running Time Excluding Circulation, Hours	Length of Fish Recovered Feet	REMARKS
1	1811	....	....	3	1	1	2	1811	
2	1963	2	4	6	4	1½	11½	152	2 runs with indicator and shot necessary.
		1½	4½	...	...	1	7	None	Rotary shoe worn out after making 35 feet.
3	2113	1½	2	...	1	1	5½	150	Running 6 joint wash string.
4	2264	2	5½	...	1	1½	10	151	
5	2416	2	5	...	1	1½	9½	152	
6	2779	5	6	...	...	4	15	....	Running 16 joint wash string. Washover Backoff tool not run this trip. Conventional method used requiring two runs, one with wash pipe and one with drill pipe.
		2	....	3	1	2	5	363	
7	3383	8	11½	...	1½	8	29	604	Running 20 joint wash string. Digging very hard. Wash pipe layed down to change shoes.
8	3990	8	5	...	1½	2½	17	607	Wash string had to be made up, accounting for extra time going in hole.
9	4565	2	4	...	1	2	9	575	
10	5141	2	4	2	1	2	9	576	Interspersed carbide shoe used from this point on.
11	5716	2	4	2½	1	2½	9½	575	
12	6291	2	6	1½	1	2	11	575	
13	6866	2	6½	1½	1	3½	13	575	
14	7442	2½	5½	2	1	3	12	576	
15	8017	2	5	...	1	2½	10½	575	
16	8586	2½	4	2	1	3	10½	569	
17	9188	3	4	1	1	3	11	602	Job completed.
Total		52	86½	22½	21	47½	207	9188	
Average		2.9	5.1	....	1.2	2.5	10.9	540.5	

to examine the show. On each run, the fishing string was brought out only to the point where the upper end of the washpipe cleared the rotary table. With the wash pipe hanging in the slips, the fish was stripped out and laid back. In backoffs 6 and 7, however, where it was necessary to pull the washpipe, the increased time spent in going in and coming out of the hole is appreciable.

If this job were performed by the conventional method of washing over and cutting from the outside, many hours would be added to the total running time. For each cut made, two runs of the washpipe would be required, and in both runs it would be necessary to pull the washpipe. In one run an outside cutter would be placed just above the rotary shoe; in the next run this tool would be omitted. This means that, instead of making 17 runs to effect 17 recoveries, as was the case on this job, at least 34 trips would be required, and it would be necessary to pull the washpipe each trip. Allowing two hours for setting the washpipe back after each run, it is estimated that the 34 trips would require about 319 hours rig time. This would mean a total running time of 427 hours. Each cut would take only about 20 minutes, as compared to one hour to run a string shot. Therefore, about 15 hours should be deducted from this total time, leaving a total of 412 hours running time to recover 9188 feet of pipe. A conservative estimate of the cost would be about $1.18 per foot, of recovered pipe.

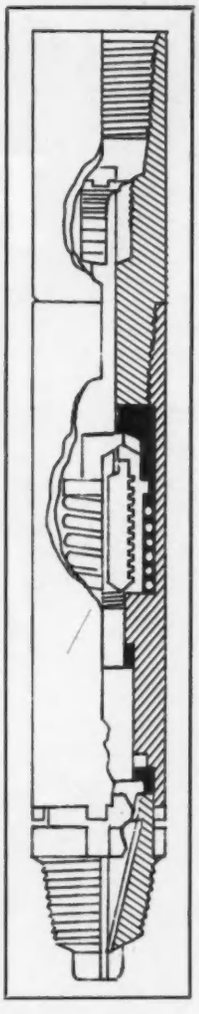

FIGURE 27—A modern expanding pin top. This tool is quite useful in a tight hole where an overshot cannot be used. Expanding pin tap makes a connection as strong as any other part of the fishing string.

If the 205 hours rig time saved were valued at $30 per hour ($6150), then the washover-backoff method would be the most economical approach. In any consideration of involving the selection of fishing methods, time would be important factor. Consequently, where drilling is deep, requiring costly rig equipment, the washover-backoff connector will produce the most tangible results. The higher the hourly rig cost the greater the dividends. Offshore, where minutes are gilded, this tool perhaps realizes its maximum potential. As much as 50 percent can be cut from the time required to complete the job by washing and cutting. This bonus may well amount to thousands of dollars.

Other significant advantages accrue from the use of the washover-backoff method as compared to outside cutting. Each time a cut is made a joint of pipe is ruined. If 17 cuts were made on 4½-inch drill pipe, as in the above resume, then the loss would amount to approximately $2550. In the backoff method there is no damage to the pipe whatever.

When cutting from the outside, the length of fish recovered in any one trip will necessarily be limited to the length of pipe washed over. This means that the fish will not exceed 600 feet in length, since it is impractical to run more than about 20 joints of washpipe.

On the other hand, when using the washover-backoff method, it is often possible to recover more pipe per trip than has actually been washed over. This is the case when the fish is not stuck solidly all the way to the bottom, but rather is bridged intermittently so that one portion will be stuck tightly while another portion will be free. Under such conditions it is often possible to wash over a few hundred feet and back off a thousand or more feet of pipe. The following tabulated data on a job using a washover-backoff connector in the Sherman area will confirm this fact:

Backoff No.	Length of Pipe Washed Over	Length of Fish Recovered
1	None	4980 ft.
2	326 ft.	1346 ft.
3	363 ft.	283 ft.
4	363 ft.	440 ft.
5	361 ft.	563 ft.
6	362 ft.	2064 ft.
7	88 ft.	508 ft.
7	1899 ft	10,184 ft.
Average of all runs	271 ft.	1455 ft.
Average of runs 2 through 7	316 ft.	867 ft.

In this recovery operation, for every 316 feet of pipe washed over, 867 feet were recovered for a ratio of 2.7 to 1. If an outside cutter had been used, it would be safe to say that, after backing the free pipe off at 4980 feet, a minimum of 10 cuts would have been necessary to complete this job. This would mean 20 round trips of the wash pipe as compared to the 6 trips required by the washover-backoff connector. Actual running time would have been trebled.

Generally, the washover-backoff method will pay the greatest dividends, recovering more fish in less time than any other method. In expediting recovery procedures, certain additional costs have been incurred which are to be reflected in the final cost. Progress has never come cheaply; it varies with the refinement, complexity, and cost of the product. Usually, the greater the progress and refinement the greater the complexity and cost. A string-shooting truck, with its maze of wires and instrument panels would have looked like a contraption for interplanetory communication to a driller of the 1890's. The cost of manufacturing this device at that time would have been prohibitive. The washover-backoff connector itself costs several times again as much to manufacture as the conventional outside cutter.

If the method costs more, it also produces more. If pipe had to be recovered after the fashion of the early 1900's, the cost in rig-time alone would be staggering.

Modern drillers and contractors are keenly aware of these facts. In the battle against time new methods and tools are constantly being sought. These tools and techniques are born of necessity and grow due to the keen competition in modern industry.

EDITOR'S NOTE: The fourth in this series of six articles will appear in the May issue of WORLD OIL and will deal with hydraulic pulling tools.

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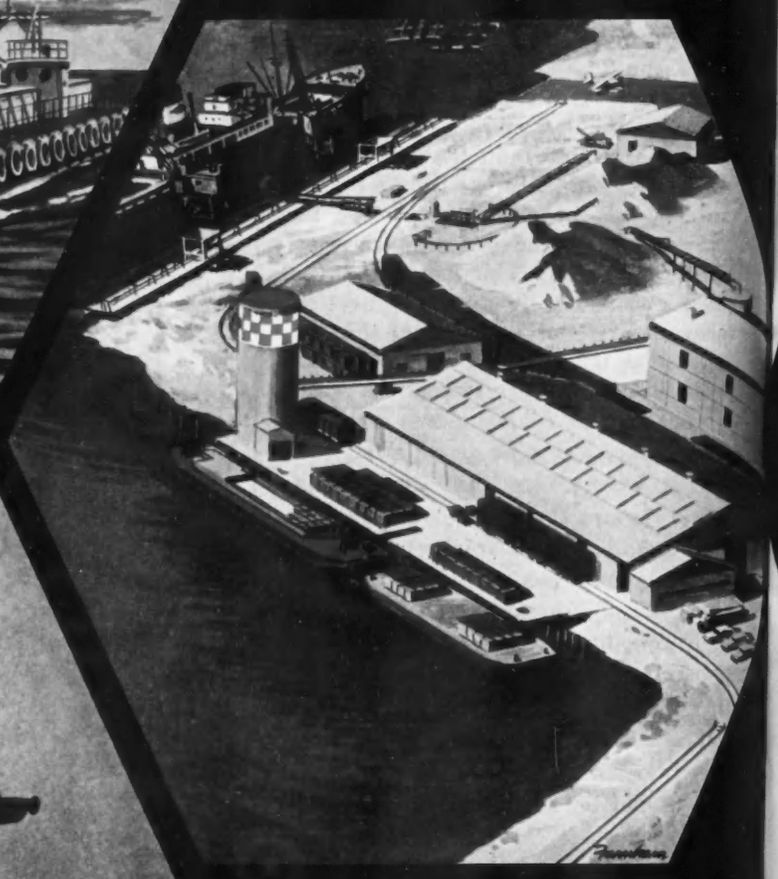

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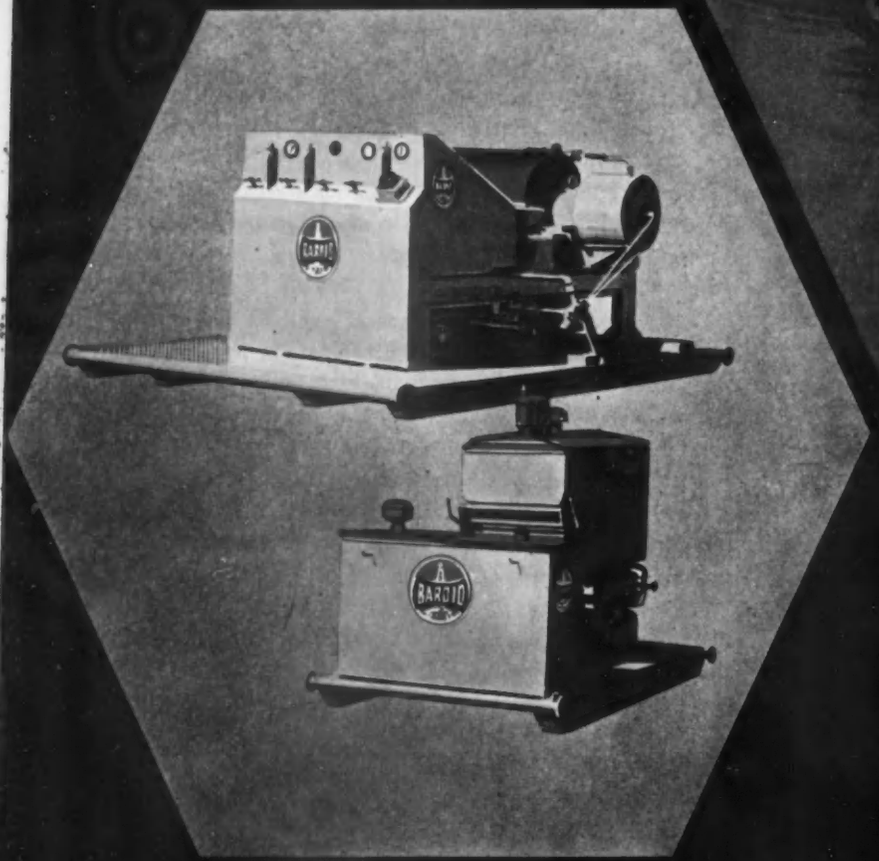

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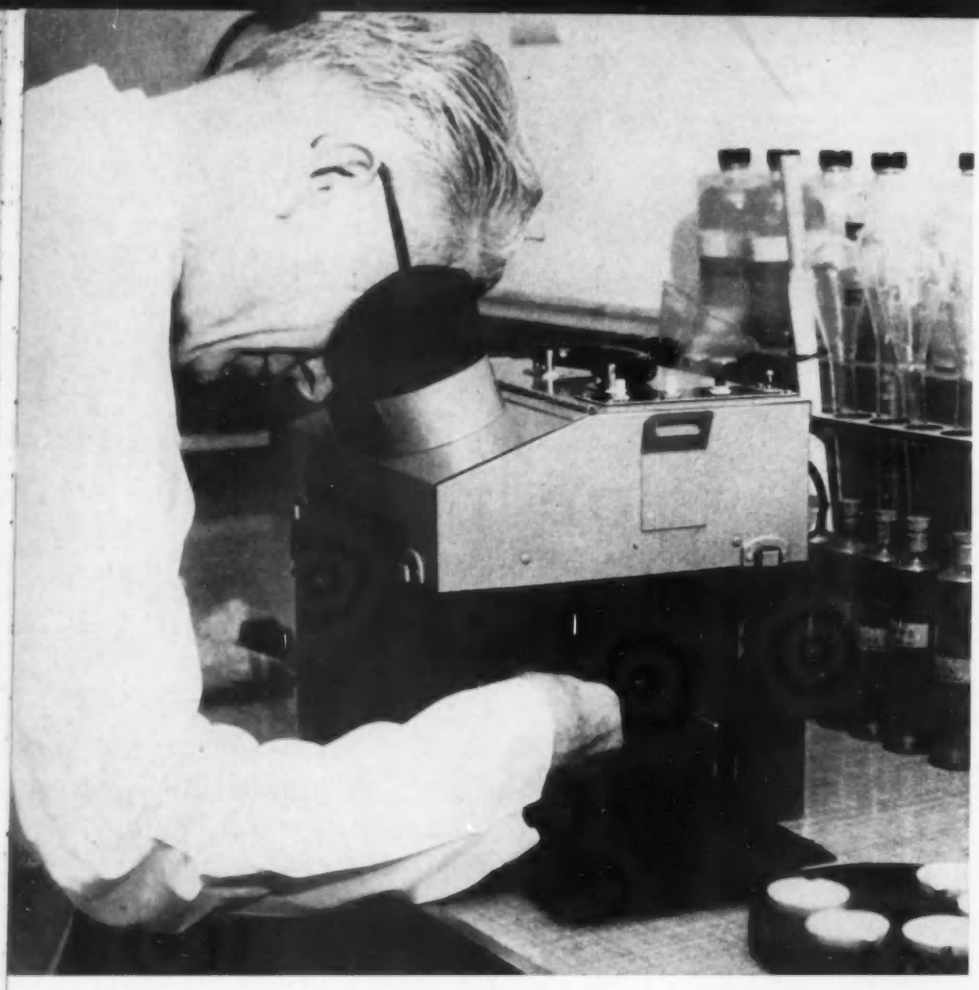

FIGURE 1—Geologist using an ultra violet light examines cuttings from a well where non-fluorescing emulsion muds were used.

What Non-Fluorescent Emulsion Muds Provide

- Better interpretation of cuttings and cores
- Increased penetration rates
- Decreased drilling torque

By G. G. BAKER
Oil Base, Inc.
Houston, Texas

WITH THE SUCCESSFUL development of a non-fluorescent oil covered by a use patent, which can be added to drilling mud, an emulsion is now available that overcomes objectionable features of former oil-in-water emulsions. Before this development it was difficult to accurately determine zones of true saturation as a result of interference with geological interpretations resulting from invasion of mud oil into cores and cuttings.

Non-fluorescent oil used in drilling mud has resulted from certain refining methods which remove all the unstable and reactive hydrocarbons, leaving only the stable paraffins and naphthenes, which are colorless and non-fluorescent. Synthesis of hydrocarbons which contain no aromatics or unsaturates provides oils which are non-fluorescent and remain so under known well conditions. Since all crude oils do not have the native characteristics necessary to yield the desired end product within reasonable economic limits, careful selection of the base crude stock and close control of the refining processes are required.

Areas of Use. The first field applications of the non-fluorescent oil were made in the Weeks Island area of South Louisiana and the Pico Canyon area of Southern California. Because of the scope of field experience with the oil since that time, no attempt will be made to describe localized operations. Instead, general information from all areas will be presented, along with specific data where available.

Non-fluorescent oil has found the greatest usage in the Gulf Coast region, where it has been subjected to temperatures up to 350° F., at depths ranging up to 18,500 feet, over periods of time varying from two to eight weeks. Geographically, the jobs have been conducted in several locales in practically every county and parish on the Texas-Louisiana coast.

Other areas of successful application include south Texas, East Texas, Oklahoma, California, Venezuela, Colombia, Peru, Trinidad and West Texas-New Mexico, where it also has been used in the special emulsions commonly called "milk emulsions."

Mud Programs. The use of non-fluorescent oil does not require any special chemicals or mud treating agents, nor is it necessary to change essentially any mud program. A simple substitution of the non-fluorescent oil for any other oil is all that is necessary in most instances.

In cases where specific emulsifiers are employed, only the soap-type materials, such as derivatives of tall oil, should not be used. Such materials are fluorescent by nature, and would therefore nullify the benefits obtained by using the non-fluorescent oil. If there is reasonable doubt concerning some specific chemical, observation under the ultra-violet light will determine whether it can be used. Ordi-

WIRE ROPE AT WORK

When our roving photographer was "doing" the Northwest Sherman Field, near Sherman, Texas, this neat Falcon Seaboard outfit caught his eye. He learned that the rig had easily put down 8400 ft of hole since starting the well, and the crew expected to go another 1100 ft.

In discussing the various rig components, somebody mentioned the rotary line. It was a Bethlehem line, 1¼-in. 6x19 Seale, with 8-part rigging. Though it had seen hard service, it showed very little wear, and everyone agreed that it was more than earning its keep. This is a typical comment on Bethlehem rotary-line performance, for there is no tougher, more durable rope anywhere than that made by Bethlehem.

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narily, the common oil field mud chemicals have been satisfactory and seldom has it been necessary to conduct pilot tests. If the mud is non-fluorescent before the addition of the non-fluorescent oil, it will remain so after addition of the oil.

Oil percentages are maintained in the usual manner and by whatever method the individual operator prefers. Clean storage tanks should be provided where rig storage is desired. Again, storage requirements are seldom standard and each case seems to be a matter of choice with the operator. In many areas no rig storage is used and oil percentages in the mud are allowed to vary over several ranges, such as 8-15, 5-12, 5-15. Make-up volumes are transferred directly from trucks into the mud system. If a storage tank is used at the rig, it should be a welded tank, and preferably one that has never contained any oil. If it is found necessary to clean a used tank, it should be thoroughly steamed and the use of a detergent has been found to be very helpful. It is practically impossible to completely remove residual oil from a bolted tank.

FIELD RESULTS

Drilling Factors. Table 1 shows the average hours/bit, average feet/bit, average feet drilled/hour, and other factors in two Louisiana offshore wells before and after addition of the non-flourescent oil. In both wells the formations drilled were principally shale with some sand stringers.

It is worthy of note that in Well A the penetration rate increased 168 percent after addition of the non-fluorescent oil. In Well B, the penetration rate increased 190 percent, and in both wells the footage per bit was more than doubled.

Many users have expressed the opinion that the nonfluorescent oil is fully equivalent to diesel oil insofar as the effect on mud properties, drilling rates, hole conditions, torque reduction etc. are concerned.

Coring. Field results indicate that use of non-fluorescent oil in mud has greatly reduced core interpretation problems caused by invasion of the mud oil and its effect on fluorescence and color (cut).

Particular emphasis is placed on the benefits obtained in sidewall coring, where often the penetration of the coring device is not sufficient to extend beyond the area of mud filtrate invasion.

Many factors, of course, enter into the sidewall coring operation and interpretations, such as condition of the mud, type of formation, type of coring device, etc. The amount of mud filtrate and the fact that oil may be filtering into the formation will not be changed where the non-fluorescent oil is used—those factors are functions of the type and stability of the basic emulsion mud. The important difference is that the oil is non-fluorescent and colorless, thus assuring positive recognition of pay zones under the ultraviolet light.

Extra logging runs, drill-stem tests, and reperforating jobs have been reduced through improved interpretation of core data.

Cuttings Analysis and Mud Logging. The non-fluorescent oil has provided notable improvements in these specific operations. The problems inherent in analyzing cuttings are, in one respect, the same as in cores, only magnified due to the size, shape and mass of material involved. Any invasion of mud oil into the cuttings raises an element of doubt concerning the origin of the oil if it fluoresces and gives a cut.

Mud logging is more accurate where the non-fluorescent oil is used. Formation oils tend to go into solution with the emulsified droplets of mud oil, and also may be partly emulsified by the emulsifier. Therefore, recognition of small quantities of formation oil becomes difficult, if not impossible, if the mud system contains ordinary oils which are fluorescent and colored.

The factors, micro-gas and gas-from-cuttings, do not seem to be materially affected by the non-fluorescing oil. They, therefore, remain as very reliable indices on hydrocarbon logs. Samples of the mud, when agitated in a blender, may release a small quantity of gas; this gas reading, however, remains fairly constant and working levels can be established as in using diesel and similar oils.

Identification of formation oil in carbon tetrachloride cuts is easier, for obvious reasons, where muds containing non-fluorescent oil are used. Sandstone cuttings, in most cases, will yield cuts of slightly lower intensity than would be expected from the appearance of the sandstone. This condition is due to leaching of the oil-wetted surface by the emulsion mud. A more intense cut can usually be obtained by crushing the cuttings.

Releasing Stuck Pipe. Several cases are on record where the non-fluorescent oil was spotted in wildcats for freeing stuck drill pipe, under conditions where other oils were objectionable because of their fluorescing characteristics. In addition, one extensive series of tests by a major oil company resulted in the conclusion that oils in the same gravity range as the non-fluorescent oil are more effective in releasing stuck pipe than are crude oils or lower gravity refined oils.

Electric Logging. There is no known instance where the substitution of the non-fluorescent oil for other oils has caused any difference in logging results.

Effect of Oil on Rubber Parts. An aniline-point test on an oil will give an indication of the effect it will have on rubber parts; and, it is generally agreed that high aniline point oils are desirable because they have less effect on rubber. The aniline point of non-fluorescent oil varies in different sections of the country within a range of 150-175° F., which is considered high. By way of comparison, diesel oils may vary from 110-180° F.

Costs. The cost of the non-fluorescent oil is slightly higher in most areas than ordinary diesel and similar oils. For example, a 100-well survey in South Louisiana showed an average additional cost of $800 per well over that incurred in using diesel oil. Experience has shown that this slight increase in cost is insignificant when

TABLE 1

	Before Adding Non-Fluorescent Oil	After Adding Non-Fluorescent Oil
Well A		
Depth Interval	10,147—11,801	11,801—13,468
Avg. Mud Wt., lbs./gal.	13.2	14.5
No. bits used	8	3
Avg. hours/bit	31.1	31.1
Avg. feet/bit	207	556
Avg. feet drilled/hour	6.64	17.8
Well B		
Depth interval	10,205—10,817	10,817—11,750
Avg. Mud Wt., lbs./gal.	14.2	14.6
No. bits used	7	4
Avg. hours/bit	23.3	21.2
Avg. feet/bit	87.3	223
Avg. feet drilled/hour	3.75	10.9

compared to the benefits obtained in geological interpretations and in actual savings due to reduction of costly testing operations.

Conclusions.

1. The non-fluorescent oil has been thoroughly field tested in most of the major active drilling areas in this country, and in several South American areas.

2. The oil can be added to field muds in the normal manner—for all practical purposes, mud programs and maintenance procedures are the same as those required for ordinary diesel oil emulsion muds.

3. Drilling rates, mud properties, and hole conditions are in every way comparable to those obtained with diesel oil. No instances have been found where any material differences existed between the non-fluorescent oil emulsions and diesel oil emulsions with regard to those factors.

4. Interpretation of data on cores, cuttings, and mud logs is vastly improved through use of the non-fluorescent oil.

5. The oil has been successful in releasing stuck drill pipe without interference in geological considerations.

6. The oil is among those having the least effect on rubber parts.

7. The cost of the oil is insignificant when compared to the benefits obtained.

—The End

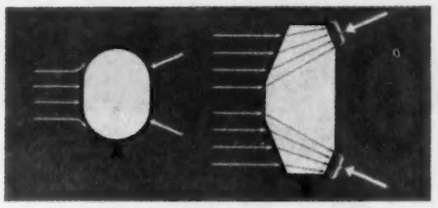
New Self-Sealing Ring Gasket Is Developed by Cameron

CAMERON IRON WORKS, INC. Houston, has announced the development of a new self-sealing ring gasket for API flanged connections.

Because of the benefits which will come from widespread acceptance, this new gasket is being released to the industry royalty-free.

This gasket uses internal pressures to assist sealing effect, requires far less make-up time, no retightening, and offers a degree of safety not possible with present API gaskets.

Stud bolts need be tightened only once around to pre-load the gasket and start the self-sealing effect. Vibration during drilling operations which normally puts destructive stresses on API rings in drilling control hook-ups does not affect bolt tension or gasket seal. Rough handling of christmas trees in shipment or extreme test pressure shocks do not necessitate retightening of stud bolts.



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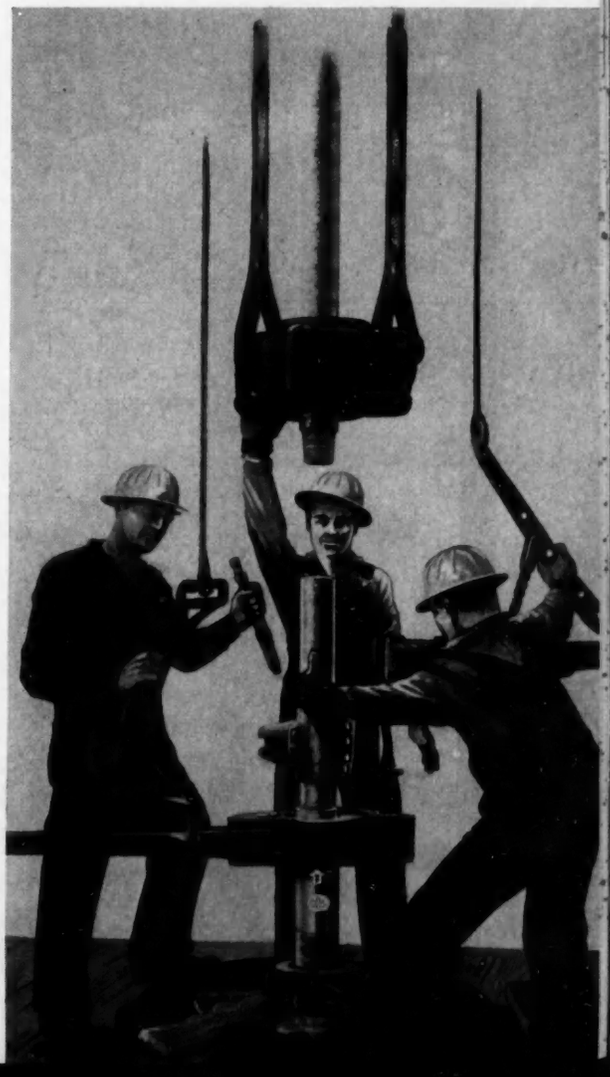

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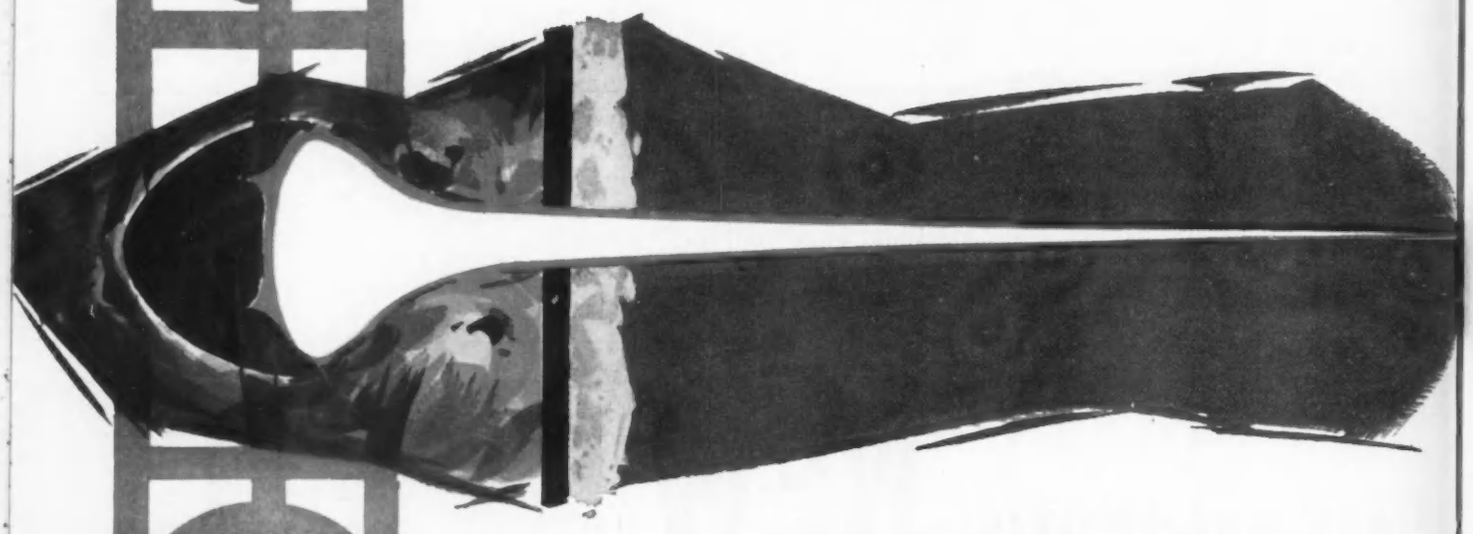

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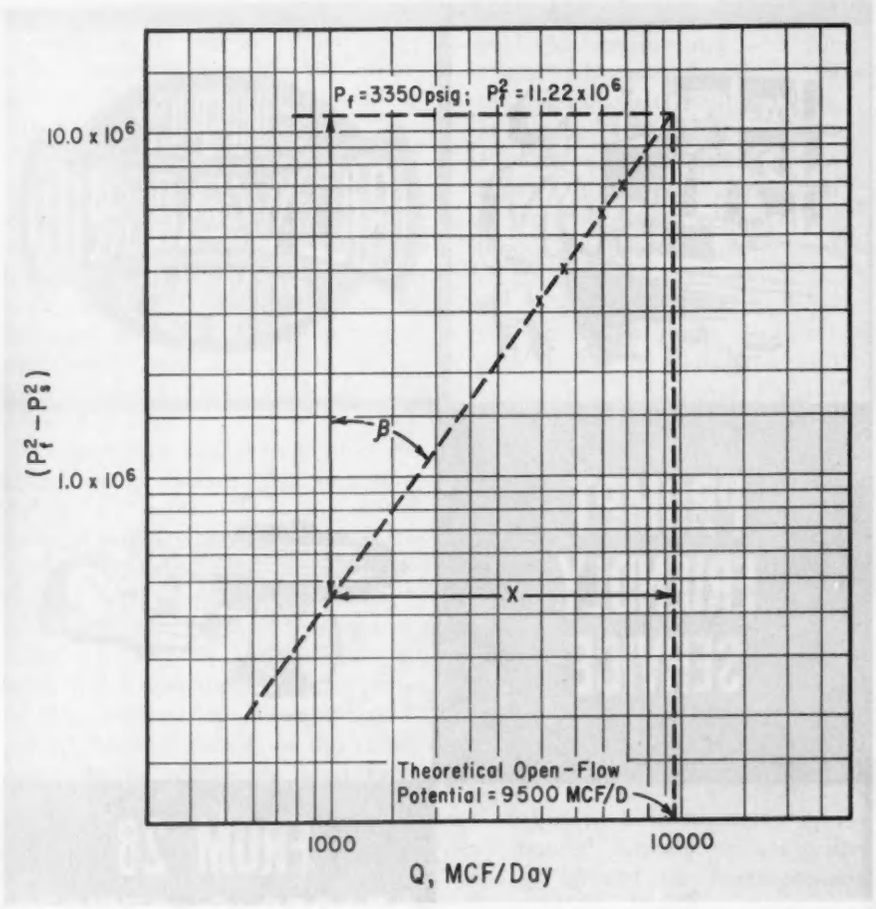

FIGURE 1—Typical open flow potential curve for a gas well. The diagonal line best represents the plotted flow rate data. It is extrapolated to the value of P_f^2, or where the sand face flowing pressure is theoretically zero.

Here is an integrated treatment of the problem of practical deliverability forecasting for gas reservoirs. It begins with the standard open-flow potential curve and ends with a complete forecast of the producing history of a well or group of wells in a common reservoir.

By JACK R. FRASER
Republic Natural Gas Company
Dallas

IN THIS PRESENTATION, the open-flow potential test and a method for computing pressure drop in the tubing strings of flowing gas wells are reviewed. The open-flow potential and pressure drop in tubing data are then combined to give deliverability as a function of reservoir pressure. Finally, the reservoir pressure is related to time at capacity rates of flow by combining reservoir pressure versus cumulative production data with deliverability data. This last operation yields the rate of production versus time for a well or group of wells in a common reservoir.

Definition and Utility of Deliverability Data. In general usage "deliverability" has a variety of meanings. As used herein, however, deliverability of a gas well will be defined as that volume of gas, measured at standard conditions, the well is capable of producing in a 24-hour period against a specified tubinghead flowing pressure under steady state conditions.

For a majority of reservoir engineers, predicting the behavior of an oil or gas reservoir is a frequent assignment. Sound estimates of ultimate recovery and rates of production are the basic data for economic studies which, in turn, may be used to determine optimum methods for exploiting the reservoir under study. It is in the forecasting of the rate of recovery from gas reservoirs that a determination of the deliverability of gas wells, as defined above, is required.

The Open-Flow Potential Test. The open-flow potential of a gas well at a particular static reservoir pressure is the theoretical steady-state flow rate which the well would develop if it were possible to reduce the absolute flowing pressure at the sand face of the well to zero. The theoretical open-flow potential of a well, then,

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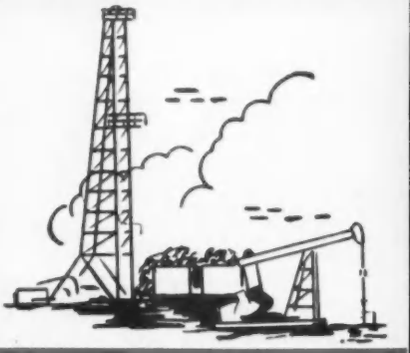

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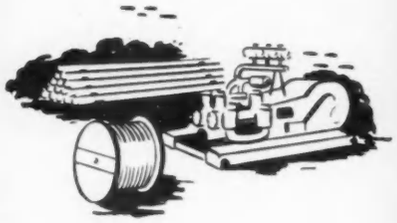

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is not of itself any measure of the well's ability to deliver gas at the surface through a string of tubing several thousands of feet (or several miles) in length, against some particular back-pressure at the surface choke.

The observed field data required to determine the open-flow potential for a gas well are the static reservoir pressure and the flowing sand face pressures at several accurately measured rates of flow under steady-state conditions. The static reservoir pressure and the flowing sand face pressures corresponding to particular rates of flow are measured with a bottom hole pressure bomb or are computed from surface pressures measured with an accurate Bourdon or dead-weight type gage. The corresponding flow rates may be measured with a critical flow-prover, a conventional orifice meter, or may be computed directly from the pressure immediately upstream of an accurately drilled positive choke at the wellhead.

The rate data are then plotted on log-log paper versus the quantity $(P_f^2 - P_s^2)$, where P_f is the static reservoir pressure and P_s is the measured or computed sand face flowing pressure corresponding to a particular flow rate and expressed as Mcf or MMcf per day. A straight line is drawn which best represents the plotted data and this line is extrapolated upward, as in Figure 1, to the value of P_f^2, or to where the sand face flowing pressure is theoretically zero. From this intersection of the open-flow curve and the P_f^2 level, a vertical line is drawn to the abscissa and this gives the theoretical open-flow potential as defined earlier. For the most complete and authoritative study of the open-flow potential of gas wells as determined in this manner, the reader is referred to U.S.B.M. Monograph 7.[1]

It has become customary for open-flow potential data to be plotted with rate as the abscissa and $(P_f^2 - P_s^2)$ as the ordinate on log-log paper. The equation of the open flow potential curve is commonly written:

$$Q = C(P_f^2 - P_s^2)^n \qquad \text{(Equation 1)}$$

where:

C = constant to be determined

n = constant $= \frac{1}{\text{slope}}$

The constant n, may be evaluated by simply scaling X and Y, (Figure 1) and dividing length X by length Y. Another equally satisfactory method is to measure the angle B and the tangent of angle B gives the exponent n. Having determined n, the coefficient C in Equation 1 may be computed directly by using any value of Q and the corresponding value of $(P_f^2 - P_s^2)$.

While the constants n and C need not be evaluated in order to find the open-flow potential, the equation of the curve is sometimes useful if certain analytical operations are undertaken.

The significance of Equation 1, the coefficient C, and the exponent n, is discussed in Reference 1. The principal conclusion of interest in deliverability work is that the relationship between Q and $(P_f^2 - P_s^2)$ is applicable regardless of the actual values of the pressures. In other words, it is not the pressures themselves, but the difference in the squares of the two pressures, which governs the rate of flow into the well bore. The implication is that a gas well open-flow potential curve based on data taken at one static reservoir pressure level should have validity at any lesser reservoir pressure providing, of course, there has been no interim mechanical change in the completion interval.

About the Author

JACK R. FRASER is principally engaged in reservoir and geological engineering work for Republic Natural Gas. He joined the company on Feb. 1, 1956, as senior petroleum engineer. Previously, he had served Texas Eastern Production Corporation as Houston district geologist, division petroleum engineer and chief engineer, subsequently. Fraser is a graduate of the University of Pittsburgh in 1941 with a B.S. in petroleum and natural gas engineering. Following his schooling, he worked for Equitable Gas Company in Pittsburgh and as exploitation engineer and production geologist with Shell Oil Company.

Pressure Drop in Tubing Strings. The pressure drop in a flowing gas well between the sand face and the surface is the sum of friction losses in the flow string and the weight of the moving column of gas. It is this pressure drop which imposes the total pressure at the sand face against which a well delivers gas into the well bore. The determination of pressure drops in flow strings is, therefore, a requirement for deliverability computations.

There have been many methods published[1, 2, 3, 4, 5] for computing pressure drop in flow strings. A satisfactory and convenient method the author has frequently used is found in Reference 3, where the following equation is derived:

$$P_s^2 = \frac{P_w^2 + \frac{15.1(QTZ)^2}{D^{5.23}}\left(1 - e^{-37.5\frac{GL}{TZ}}\right)}{e^{-37.5\frac{GL}{TZ}}} \qquad \text{(Equation 2)}$$

The symbols are defined as follows:

P_w = Wellhead flowing pressure, psia
P_s = Sand face flowing pressure, psia
G = Gas gravity, Air = 1
L = Length of flow string, 1000's of feet
T = Average temperature in flow string, °R
Z = Compressibility factor at average pressure and temperature in flow string
D = I. D. of flow string, inches
Q = Rate of flow, MMcf/day
e = 2.718

Satisfactory agreement has been found by the writer between measured pressures and pressures calculated from Equation 2, over a wide range of pressures, rates and tubing dimensions.

Flow Rates Versus Sand Face Flowing Pressures For Various Tubinghead Pressures. Using any acceptable method, such as Equation 2, complete pressure-drop correlations may be computed for a particular tubing string relating sand face flowing pressure, flow rate and tubinghead flowing pressure. The procedure is to fix the tubinghead flowing pressure at some desired level and compute the sand face flowing pressures for three or four different rates of flow. Next, the tubinghead pressure

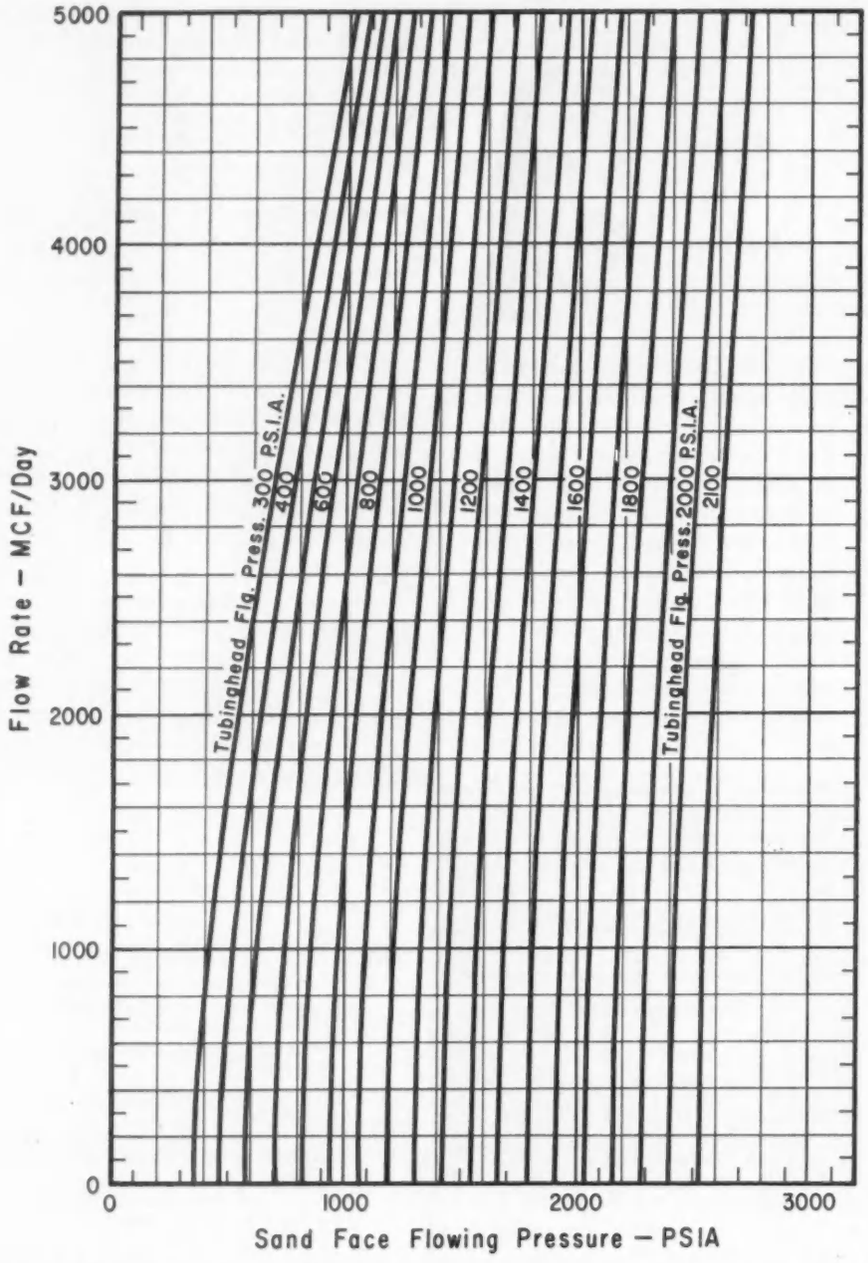

FIGURE 2—Flow rate versus sand face flowing pressure for an average well in a specific field. L = 7150 feet. D = 1.995 inches. T = 625° R. G = .706.

is fixed at another level, and sand face pressures are again computed for several different rates of flow. The resulting P_s versus Q data are plotted for each tubinghead pressure selected.

It is convenient in fields where all of the wells are equipped with the same diameter tubing and producing from about the same depth, to compute one such family of curves for an "average well" in the field. As an example of this, Figure 2 shows a complete correlation prepared by the author for an "average well" of a group of 13 similarly equipped wells producing from approximately the same depth in the Hagist Ranch field of McMullin and Duval counties, Texas. As indicated, the parameters in Figure 2 are tubinghead flowing pressure, sand face flowing pressure and flow rate. Given any two of these factors, the third may be obtained directly by simple interpolation.

Open Flow Curves Used Together With Pressure Drop in Tubing Data to Give Deliverability Curve. To demonstrate the development of deliverability data from the open-flow potential curve and the tubing pressure drop curves, assume that the open-flow curve of Figure 1, represents a well for which Figure 2 gives the relationship between sand face flowing pressure, tubinghead flowing pressure and rate of flow. Our problem is to determine the deliverability of this well against a particular wellhead back pressure as reservoir pressure declines. As an example, choose 1600 psi as the surface tubing pressure against which the well must flow to deliver gas into a pipe line.

The procedure is as follows: Enter Figure 2 with a Q and determine the sand face flowing pressure corresponding to that Q and 1600 psia flowing tubinghead pressure. Square this pressure and we have P_s^2. Enter Figure 1 with the same Q and determine $(P_f^2 - P_s^2)$. Add P_s^2 from Figure 2 to $(P_f^2 - P_s^2)$ from Figure 1, and get P_f^2. The square root of this is P_f, or the static reservoir pressure at which the well is capable of delivering gas at the rate Q against 1600 psia tubinghead pressure. Repeat this procedure for various values of Q as shown in Table 1.

The resulting Q vs. P_f data are plotted on ordinary coordinate paper as in Figure 3. This process can be repeated for any desired flowing tubinghead pressure and a complete set of deliverability curves obtained.

Predicting Future Producing Rates. Thus far in this development, we have related only pressures and rates. To complete the picture and schedule the future producing history of a gas property, we must consider time as an additional variable.

Apparently there are as many dif-

TABLE 1
Deliverability Against 1600 Psia

Q MMCF/D	(From Figure 2) P_s (Psia)	(From Figure 2) P_s^2	(From Figure 1) $P_f^2 - P_s^2$	(From Figure 1) P_f^2	(From Figure 1) P_f (Psia)
5	2160	4.65×10^6	4.50×10^6	9.15×10^6	3030
4	2100	4.41	3.30	7.71	2782
3	2040	4.16	2.40	6.56	2564
2	1980	3.92	1.23	5.15	2271
1	1930	3.72	.46	4.18	2050
0	1912	3.66	.....	.....	1912

ferent degrees of water-drive effectiveness in gas reservoirs as there are water-drive gas reservoirs, and it is not possible to generalize on these reservoirs as to producing characteristics. The remainder of these remarks, therefore, apply to a depletion type gas reservoir since this type may be generalized as to behavior. The reader should realize, however, that this forecasting technique may be used with any gas reservoir for which the reservoir pressure versus cumulative production relation can be established.

Within the limits of accuracy of deliverability forecasts, pressure versus cumulative production data for most volumetric gas reservoirs may be considered as a linear relation having the general equation:

$$C = g + hP_f \qquad \text{(Equation 3)}$$

where:
g and h are constants, and,
C = cumulative production to a reservoir pressure of P_f

Deliverability relations such as that shown in Figure 3, may have appreciable curvature and can usually be fitted fairly well over the interval of interest with a simple parabolic curve such as:

$$Q = m + nP_f + qP_f^2 \qquad \text{(Equation 4)}$$

where: m, n and q are constants, and
Q = capacity rate of flow against a particular tubinghead pressure when the reservoir pressure is P_f.

Now Q, in Equation 4, is related to C in Equation 3, as follows:

$$Q = \frac{dC}{dt}$$

By differentiating Equation 3 and equating this with Equation 4, we are able to find time, t, as a function of reservoir pressure, P_f, as follows:

$$\frac{dC}{dt} = h\frac{dP_f}{dt} = m + nP_f + qP_f^2$$

From which:

$$dt = \frac{hdP_f}{m + nP_f + qP_f^2} \text{ and, therefore,}$$

$$t = \int \frac{hdP_f}{m + nP_f + qP_f^2} \qquad \text{(Equation 5)}$$

It is a simple matter to determine the equations of the pressure-cumulative and the pressure-deliverability relations by elementary techniques and, by the above process (Equation 5), relate time to reservoir pressure and then time to cumulative production. This process is unnecessary, however, and it is much quicker, and just as satisfactory, to obtain the desired time relations directly from the plots of Q vs. P_f and C vs. P_f, without resorting to curve-fitting.

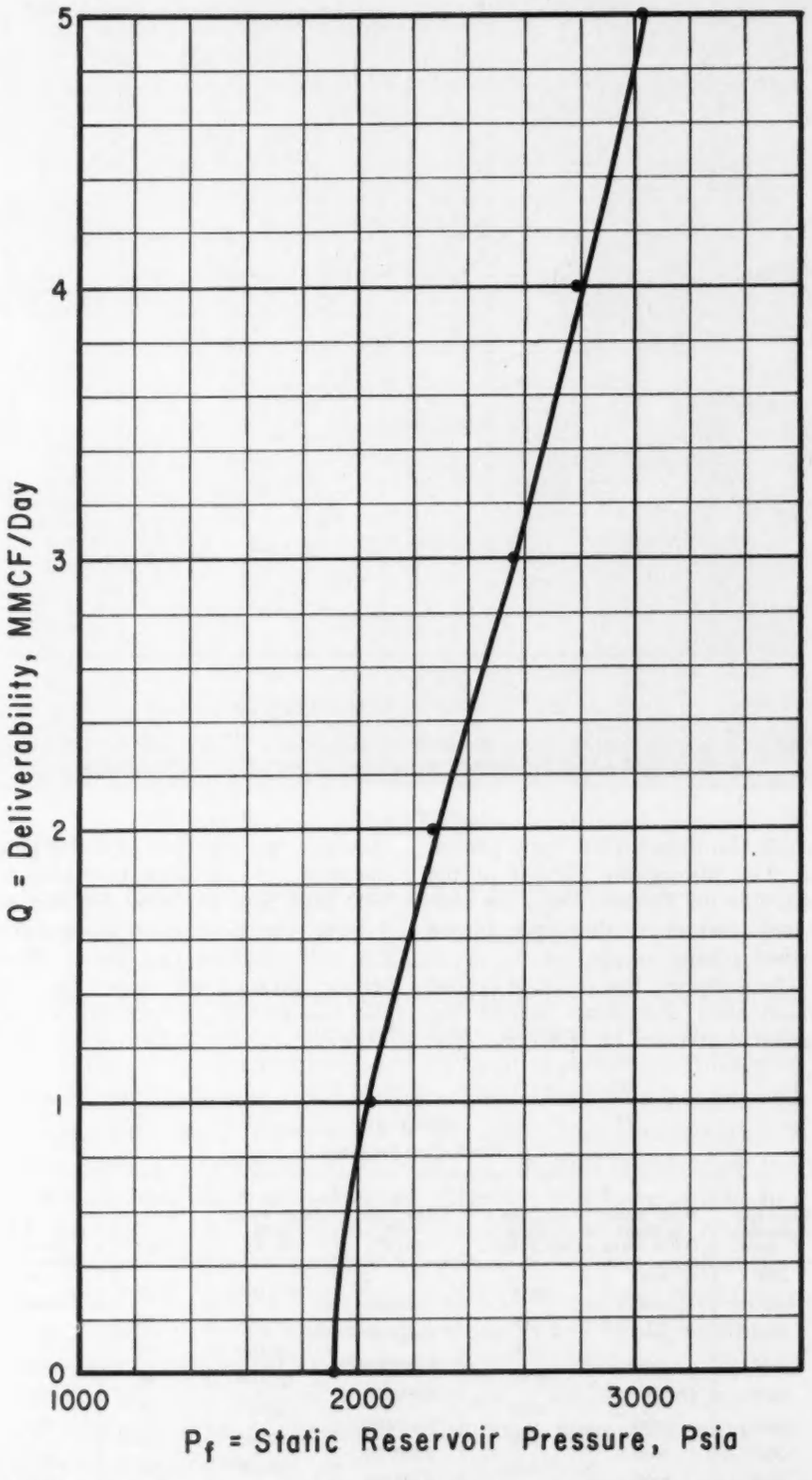

FIGURE 3—Deliverability against 1600 psia tubing head pressure versus static reservoir pressure. Plotting such data for any desired flowing tubing head pressure will provide a complete set of deliverability curves.

An Example. In order to demonstrate this technique of forecasting the rate-time history of a gas well-reservoir system, assume that Figure 3 represents the deliverability versus reservoir pressure curve for a one-well gas reservoir which had an initial reservoir pressure of 3350 psia. Reservoir pressure versus cumulative

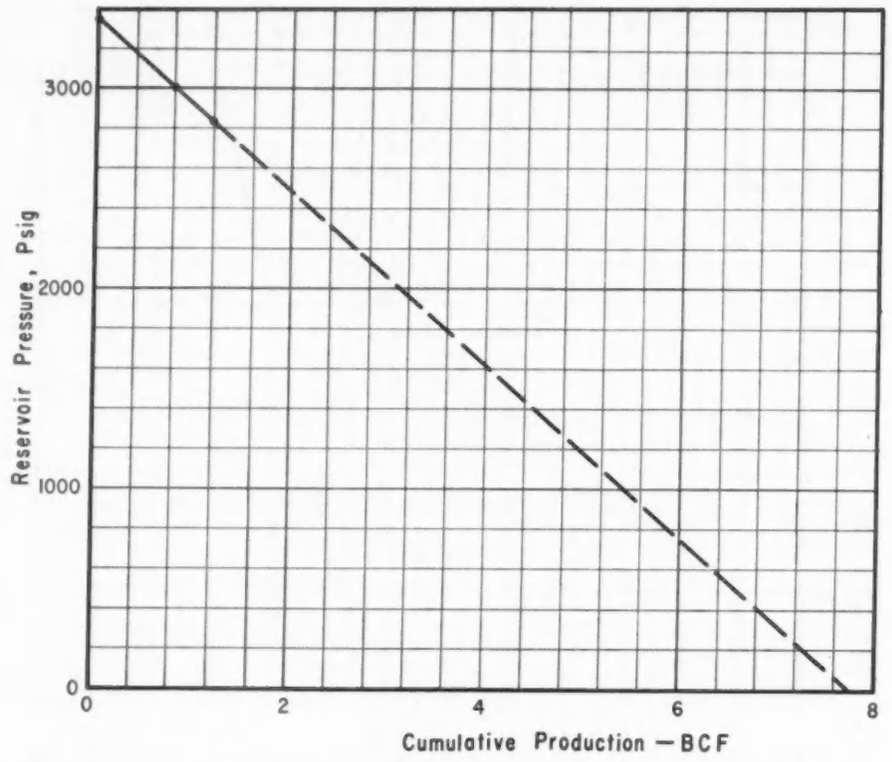

FIGURE 4—Reservoir pressure versus cumulative production data for early part of well history are shown as solid line. Extrapolated dashed portion of curve is estimated future.

production data for the early part of the well history are plotted as the solid line on Figure 4, and the estimated future is the extrapolated dashed portion of the curve.

The gathering line pressure against which time well must deliver gas carries a pressure of 1600 psia. The allowable for the well and the pipe line contract call for a daily take of 3000 Mcf/day. Let it be required to forecast the production history for this well assuming that the required delivery pressure will always be 1600 psia and that no compressors will be installed.

TABLE 2
Production Forecast

(1) Reservoir Pressure P_f (psia)	(2) Prod. Rate or Del. (MCF/Day)	(3) Avg. Prod. Rate (MCF/Day)	(4) Cum. Prod. to P_f (MCF)	(5) Cum. Prod. to P_f (MCF)	(6) Δt (Days)	(7) Cum. Δt (Days)
3350	3000		0			0
		3000		1,800,000	600	
2570	3000		1,800,000			600
		2900		140,000	52	
2510	2800		1,940,000			652
		2700		140,000	52	
2450	2600		2,080,000			704
		2500		120,000	48	
2400	2400		2,200,000			752
		2300		110,000	48	
2350	2200		2,310,000			800
		2100		170,000	81	
2280	2000		2,480,000			881
		1900		80,000	42	
2240	1800		2,560,000			923
		1700		140,000	82	
2180	1600		2,700,000			1005
		1500		120,000	80	
2130	1400		2,820,000			1085
		1300		120,000	92	
2080	1200		2,940,000			1177
		1100		100,000	91	
2040	1000		3,040,000			1268
		900		80,000	89	
2000	800		3,120,000			1357
		700		80,000	114	
1970	600		3,200,000			1471
		500		80,000	160	
1940	400		3,280,000			1631
		300		40,000	133	
1920	200		3,320,000			1764

(Columns 1, 2, and 3, are taken from Figure 3. Column 4 is read from Fig. 4. Column 6 is Column 5 divided by Column 3.)

From Figure 3, we see that the static reservoir pressure, P_f, will be 2750 psia when the deliverability of the well falls to 3 MMcf/day against a wellhead flowing pressure of 1600 psia.

According to Figure 4, by the time the reservoir pressure has fallen to 2570 psia, the cumulative production will be 1800 MMcf. The time required to produce 1800 MMcf at the rate of 3 MMcf/day and thereby reduce the reservoir pressure to 2570 psia, is 1800 MMcf/3 MMcf/day, or 600 days.

According to Figure 3, the well will be unable to deliver against 1600 psia line pressure when the reservoir pressure falls to 1910 psia. Our problem is to schedule the production from the well in the interval between the time the reservoir pressure is 2750 psia (600 days) and the time the reservoir pressure reaches 1910 psia. This may be accomplished as shown in Table 2. Figure 5 is a plot of the data from Table 2 and shows the complete forecasted producing history for this reservoir. (Page 208)

Compressors and Contracts. It will be realized by the reader that if a reserve is of sufficient size, the operator may be justified to install compressors in order to deplete it adequately. The effect of such an installation, so long as the contractual requirements as to delivery pressure remain the same, is merely to reduce the back pressure at the wellhead to some lower figure. Where the installation of compressors will be justified, the production forecast is modified by selecting another wellhead flowing pressure (which will be approximately the minimum anticipated compressor suction pressure) and this pressure will be used in computing the deliverability curve for the well. The remainder of the forecasting process is the same as was demonstrated earlier.

Contracts between buyers and sellers of gas sometimes recognize that a decline in deliverability is the inevitable consequence of the decline in reservoir pressure which accompanies the production of gas from a volumetric gas reserve. Where this is the case, the gas purchaser may agree to lower his line pressure after a certain time has elapsed or he may

Continued on Page 208

Seismic shot hole is drilled from this aluminum pontoon barge

how this three year cruise proved a point

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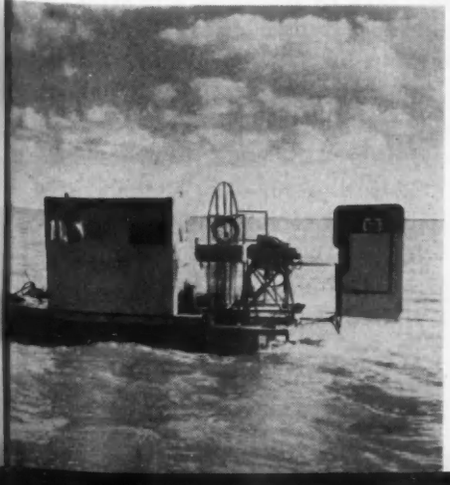

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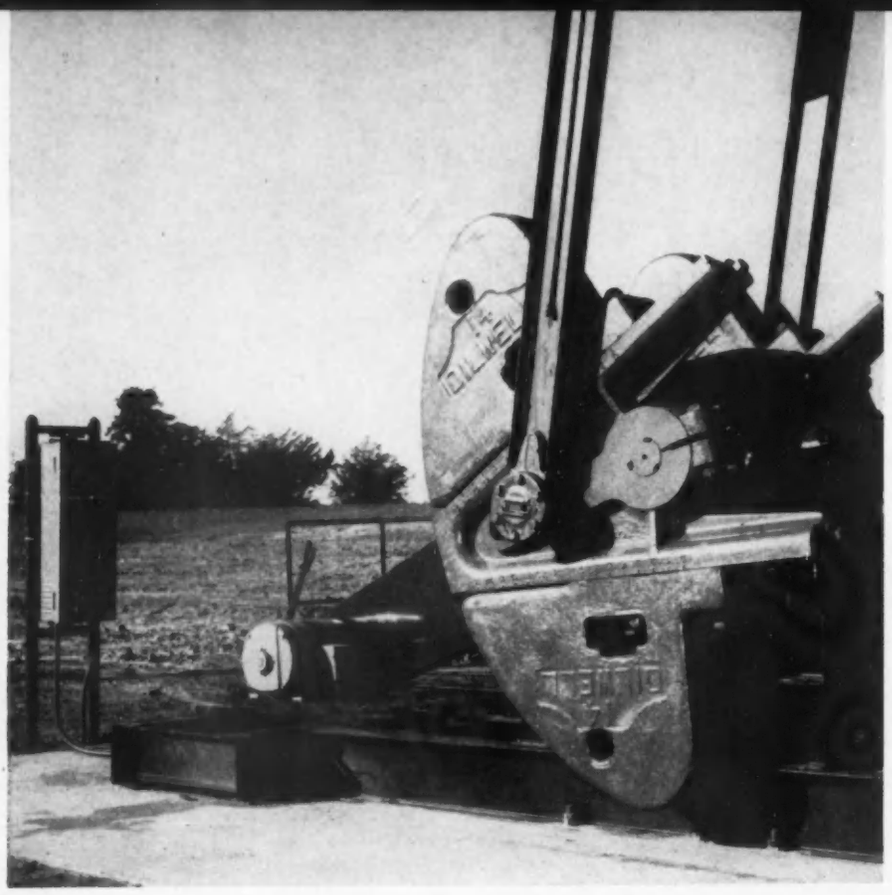

FIGURE 1—Here is a typical electrified oil well beam pumping installation. The motor is suitable for use outdoors and is generally of the high-starting torque, normal-slip variety.

The principal causes of motor failures in the oil fields are:

(1) Lightning strikes or surges on the line.
(2) Single-phasing of power system supply.
(3) Overload or high current conditions due to—
  (a) Low voltage conditions on line; voltage drop on long feeder runs; or transformer bank on conductor sized too small for load.
  (b) Voltage unbalance on three-phase power supply caused from single-phase power tap-offs; or operating unbalanced loads on open-delta transformer bank.
  (c) Motor incorrectly sized to load.

Are these problems the result of design or of equipment specifications? Further, what can be done to lessen equipment failures from these causes?

Engineering vs. Economics In Today's Electric Lease

The cheapest electrical pumping installation is rarely the most economical. Consider proper protection and optimum operating results as well as initial cost when you install an electrified lease pumping system.

By J. H. DAY, JR.
General Electric Company
Dallas

IN LEASE PUMPING today, as in most electrified industrial applications, maximum automation and maximum equipment protection are high on the list of requirements. The degree of automation and equipment protection attained is, of course, a compromise between ideal engineering practices and economics—with experience usually dictating what is acceptable.

Too often, however, equipment standards and selections are based with economics, particularly first cost, being the prime consideration. Additional features or modifications to the basic equipment are sacrificed that would provide the additional protection or functional action to prevent a costly shutdown or equipment failure or allow realization of maximum operating economy.

Motors. There are a few requirements for the motor and controller that are now accepted as being basic and essential. Figure 1 illustrates a typical electrified oil well beam pumping installation. The motor as a prime mover must be suitable for use out of doors in all kinds of weather, generally of the high-starting torque normal-slip variety and complete with rodent screens, lifting eye-bolts and other accessory features as normally required.

Starters. The starter or controller on the other hand, in addition to starting and stopping the motor either manually or automatically on some pre-selected time cycle basis, should suitably protect the motor from instantaneous faults such as lightning and short circuit currents. It should also protect the motor from sustained faults such as overload conditions or undervoltage conditions.

In addition to performing these necessary functions, the construction of the starter, like the motor, must be

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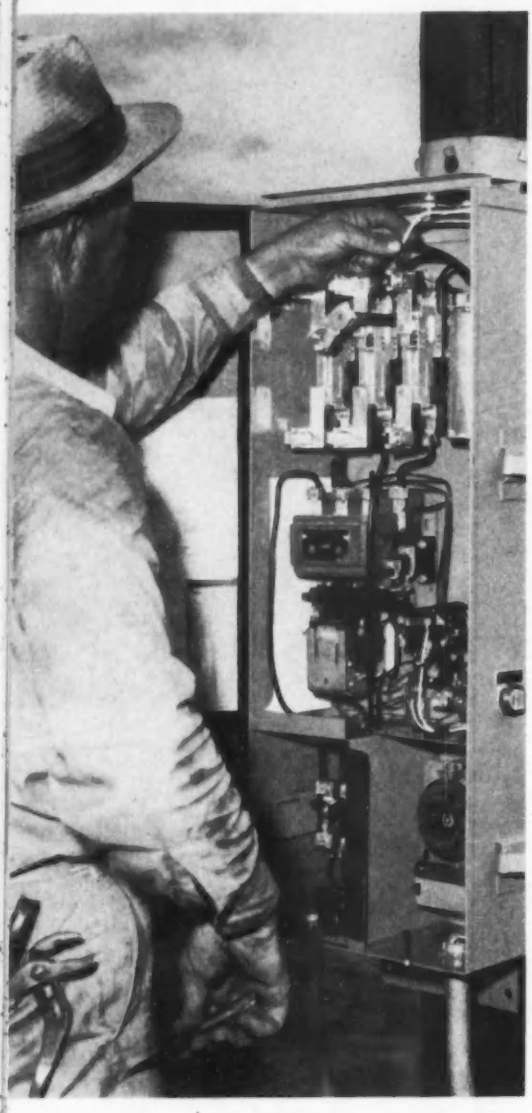


FIGURE 2—A close-up of an oil well pumping controller equipped for automatic or unattended lease pumping.

suitable for oil field pumping. The devices must be unit-assembled for ease and economy of installation and the enclosure must be weather-resistant. It should be dust tight, particularly where dust is a problem. It should have means for padlocking to prevent unauthorized entry and ease of setting if program pumping is to be employed. Figure 2, shows a typical oil-well pumping controller equipped for automatic or unattended lease pumping.

Added Features. In addition to these basic requirements, there are several "extra" or additional features which should be strongly considered when specifying or installing electrical equipment for oil well pumping applications. At a moderate price addition, the following items will prove to be an investment well worth while in eliminating the causes of many motor failures and considerably reducing downtime repairs to the equipment and operating costs:

1. Increased lightning protection by use of supplementary lightning arresters.
2. More effective lightning protection by proper grounding.
3. Increased overload and single-phase protection by use of three-element overload relay.
4. Increased undervoltage and single-phase protection by use of voltage sensitive undervoltage relay.
5. Improved operating conditions and economics by use of capacitors.

1. Use of Supplementary Lightning Arresters. The probability of equipment in the oil fields being subjected to damage from lightning depends on several factors, chiefly:

- Recurrent thunderstorm activity in the area.
- Exposed power lines—particularly over hills or high terrain.
- Length of secondary lines.
- Lightning protective apparatus installed.
- Grounding—both power system and equipment.

Standard practice is to provide a lightning arrester (usually a three-phase type) in the controller and connected ahead of the primary disconnect switch or circuit breaker as shown in Figure 2 (upper right hand corner of case). Many operators have instituted a practice of connecting an additional lightning arrester ahead of the motor starter, particularly on leases with long secondary runs. This second unit is generally three single-pole pellet-type arresters, pole mounted, and connected one in each phase of the incoming power line. Figure 3 shows typical three-phase and pellet-type lightning arresters.

This valve-type pellet arrester should be located on the pole cross-arm at the junction of the overhead line with the cable circuits as shown in Figure 4. It should be spaced one pole span length (at least 100 feet) away from the controller to permit this arrester to spark over to ground before the peak of the surge reaches the second arrester in the controller.

The addition of the pellet-type

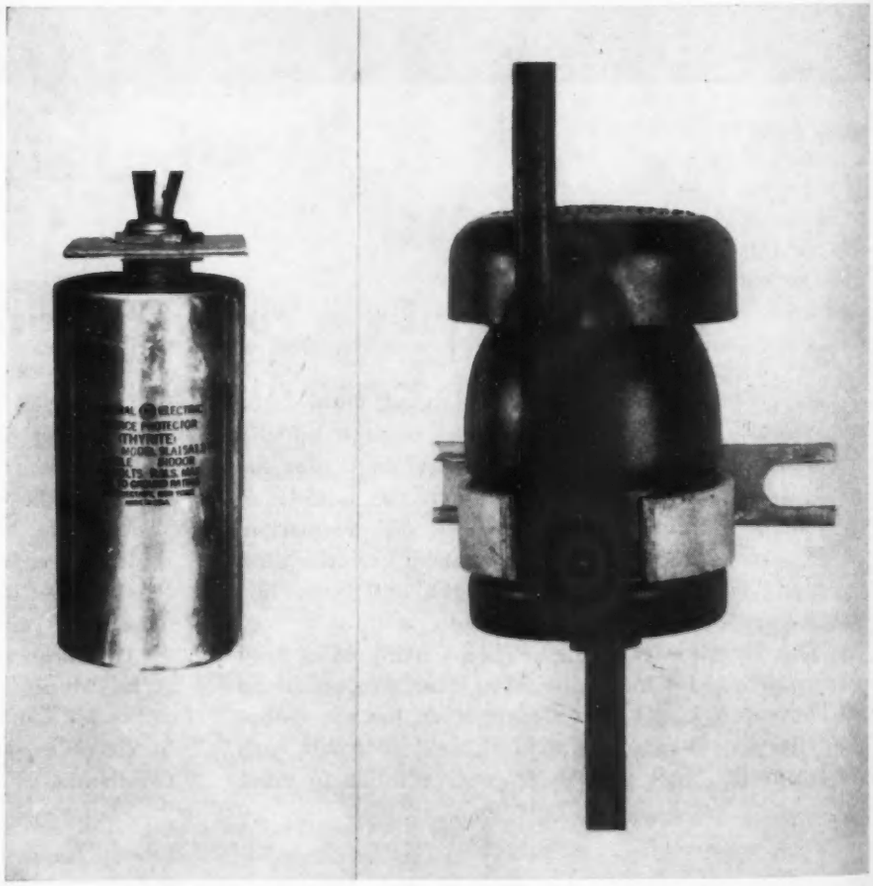


FIGURE 3—The three-phase (left) and pellet-type (right) lightning arresters are common sights on electrified oil leases.

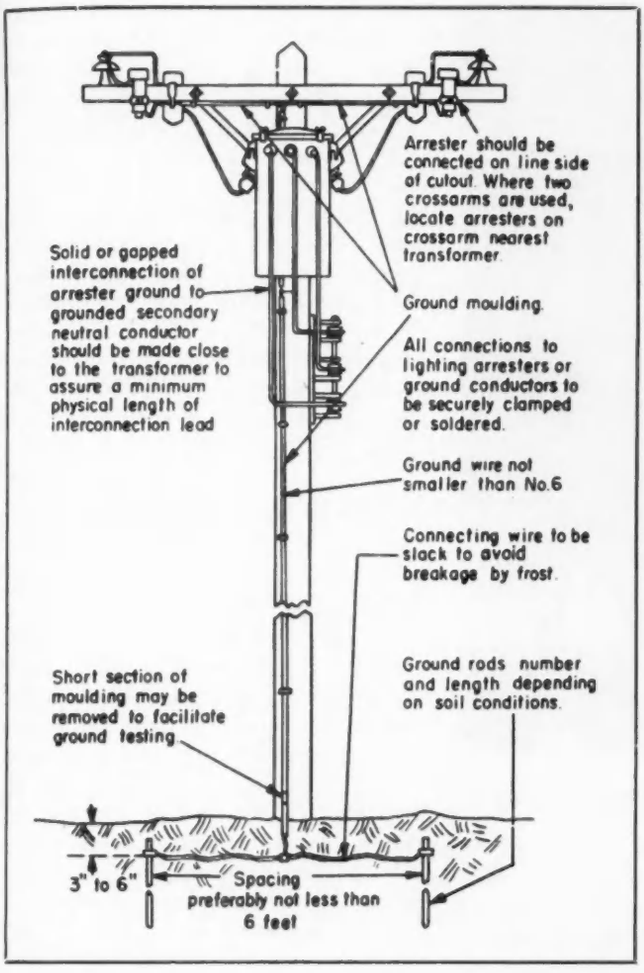

Arrester should be connected on line side of cutout. Where two crossarms are used, locate arresters on crossarm nearest transformer.
Solid or gapped interconnection of arrester ground to grounded secondary neutral conductor should be made close to the transformer to assure a minimum physical length of interconnection lead
Ground moulding.
All connections to lighting arresters or ground conductors to be securely clamped or soldered.
Ground wire not smaller than No.6
Connecting wire to be slack to avoid breakage by frost.
Ground rods number and length depending on soil conditions.
Short section of moulding may be removed to facilitate ground testing
3" to 6"
Spacing preferably not less than 6 feet

FIGURE 4 (left)—Pole installation indicating normal location of lightning arresters on cross-arm and proper method of grounding.

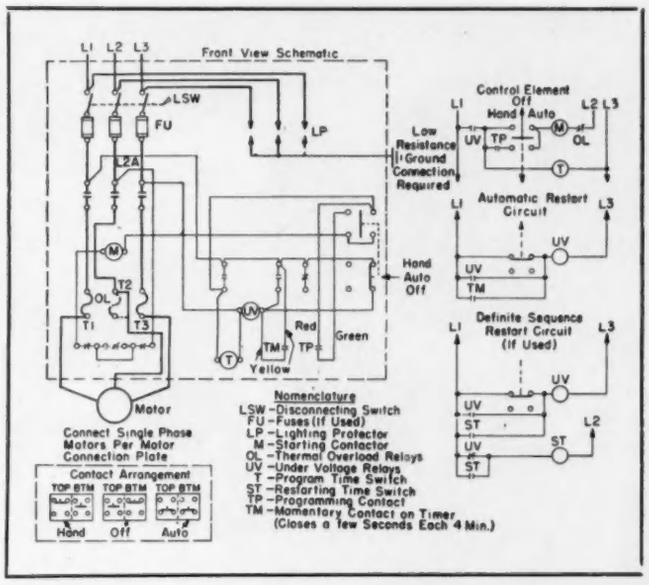


FIGURE 5—This is a typical elementary wiring diagram for an oil-field starter.

arrester (which is a relatively inexpensive item) will greatly increase the protection to the starter and motor from lightning surges by providing additional parallel paths to ground. In other words, the second set of arresters on the pole will act as the first line of defense to help discharge severe surges that may not be safely handled by the three-phase arrester in the starter which has a lower discharge voltage rating than the pellet-type arresters.

When secondary line exposure justifies it, it is felt that the installation of this second lightning arrester will greatly cut down on outages and downtime due to lightning strokes as well as help prevent costly repair of equipment.

2. Proper Grounding. The over-all protection afforded by lightning arresters depends upon effective grounding. In order to provide a suitable ground, it is strongly recommended that the grounding stud of the starter-mounted lightning arrester be connected to the well-head or casing, preferably by solidly welding on. Although grounding of both starter case and motor frames are important safety practices, the grounding of these devices and the lightning arrester to machinery frames or base plates or to surface pipe lines is not considered to provide a safe or reliable ground. Furthermore, in particularly dry areas like West Texas, grounding rods cannot be relied upon to provide an acceptable ground. It is to be emphasized that a proper low-resistance true ground is both necessary and desirable from the standpoint of safety to personnel and proper protection of the equipment from lightning. Many operators who have adopted the practice of solidly grounding to the wellhead or casing have reported a drastic reduction in outages and failure of equipment from electrical storms.

In the past, there has existed some misconception in regard to ground connections causing increased electrolytic action or corrosion resulting in the eating away of the well casing. In the first place, it should be stated that no current should flow through the ground connection except under fault or emergency conditions. And, secondly, AC current being cyclic in nature cannot cause electrolysis, as battery action depends upon DC current flowing between the two electrodes. Therefore, unless rectified, AC current cannot contribute to increased electrolytic action.

3. Use of Three-Element Overload Relay. A typical elementary wiring diagram for oil-field starter is shown in Figure 5. Standard practice on both industrial-type and oil-field starters is to provide a two-element or two-pole overload relay, usually with provision for the addition of the third-pole overload element. It is unfortunate that industry requirements in oil-field pumping have not established the three-element overload relay as standard, with an allowable omission price if only two-element overload protection is known to be adequate.

As is generally known, it is possible for a three-phase induction motor to continue to operate, particularly if lightly loaded, after the primary of a wye-delta or delta-wye transformer has been single-phased. Under this condition, the theoretical double-cur-

FIGURE 6—Capacitors will greatly reduce line losses permitting considerable reduction in transformer and conductor capacity requirements.

rent may occur in the secondary line without an overload element if two-pole overload protection is employed while the motor action on the peculiar oil-well cycling load may attempt to partially re-establish the voltage in the secondary phase reflecting the open primary. Thus, the motor will continue to run with the primary single-phased.

To provide maximum overload and single-phase protection, it is recommended that three-element overload protection be adopted as standard control on all oil-well pumping motors—particularly size two and larger starters (i.e., above 7½ horsepower, 440 volts). Compared to the total costs of the pumping unit, this additional small investment certainly seems justified.

4 Use of Voltage Sensitive Undervoltage Relay. Many oil-field controllers depend upon the voltage pickup and drop-out characteristics of the main line contactor coil for low voltage protection. While some degree of low-voltage protection is thus afforded, most line contactors not functioning primarily as a voltage sensitive device, have considerable variance in their coil pick-up (seal-in) and drop-out characteristics. Pick-up values as low as 65 to 75 percent of rated line voltage and drop-out as low as 45 to 60 percent of line voltage are sometimes obtainable. If the contactor tips kiss or chatter during near pick-up or near drop-out conditions, this, of course, causes considerable pitting and wearing of these parts. Even depending upon the overload relay elements to trip out on the high currents during low voltage conditions is not considered positive low voltage protection. This is particularly true if there is any power regeneration during the pumping cycle or if the overload heaters are not properly sized to the motor actual full-load current.

To assure positive drop-out and pickup at high values of low voltage conditions, it is recommended that a voltage-sensitive relay be employed in the control circuit. The coil of this relay should have definite high pick-up and high drop-out characteristics in order to provide the maximum degree of low voltage protection. And as an added advantage, the coil of this undervoltage relay should be connected in a phase different from the coil of the main line contactor to also provide definite secondary single-phase protection. The proper connection of this device in the control circuit is shown in Figure 5.

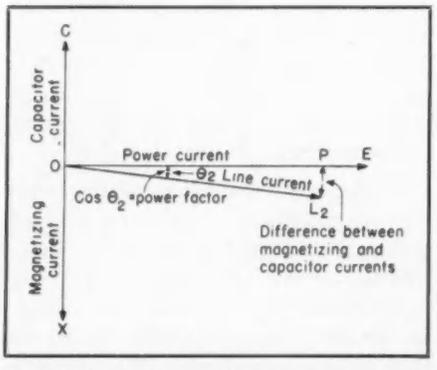


FIGURE 7—A vector diagram illustrates the effect of capacitors in reducing motor line current.

Here again a relatively inexpensive device may make considerable difference in downtime and equipment maintenance costs.

5. Use of Shunt Capacitors. The use of motor-switched capacitors has greatly increased in the oilfield during the past seven or eight years so that today there generally is not much doubt as to their economic justification. It has been proven that in addition to raising the over-all system power factor (which can save considerably on power bills if a power factor clause is in the power contract), capacitors will greatly reduce line losses and thereby permit considerable reduction in transformer and conductor capacity requirements. More efficient operation of the motors will also result. In addition, some degree of lightning protection is afforded. A typical oilfield type capacitor is shown in Figure 6.

Low operating power factor and high reactance distribution systems can result in:

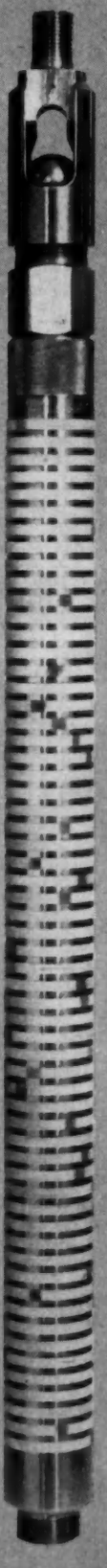
1. Excessive voltage drop on the line.
2. Oversized distribution equipment.
3. Unnecessarily high power losses.

With the resultant reduction in line current and secondary losses, capacitors usually will pay for themselves in about two years or less. If a power factor penalty clause is enforced, the time would be considerably shorter—perhaps around six months. The operating benefits of more efficient motors, greater torques available, and reduction in power bill costs will continue long after the first cost of the capacitors has been amortized. Figure 7 demonstrates the effect of capacitors in reducing motor line current.

In using and applying capacitors,

Metal to Metal Wear...

is the real villain in sucker rod pump troubles. It accounts for most of your repair and pump pulling expense.



The Martin Idea...

for getting away from this trouble has always been to make use of the best available materials — *Natural Rubber* for the key material in plunger rings; *Synthetic Rubber* for the key material in resilient ball guides for cages.

The accurately grooved and drilled metal body of **The Martin Plunger** does not touch the barrel. Only the resilient rubber and duck rings contact the barrel. This material — with its great natural resistance to abrasion as well as its slipperyness-when-wet — has a much slower wearing action on the barrel. Most often your barrel will not need replacing. These rings have an amazing ability to take the kind of abuse that goes with oil well pumping, and this means longer runs. Plunger cost is reduced because replacing the rings costs only about one fourth as much as a new plunger, and this saving is, of course, added to the barrel saving and longer runs.

Patent No. 2,591,174

The Martin Rubber Guide Cage protects the ball from all metal contact except when it rests upon its seat. The ball is protected to such an extent that ball and seat life is usually doubled. The synthetic ball guide and stop cannot beat out because of its resilience. Its life is therefore much greater than any metal and you get this longer cage life in addition to better ball and seat life. The two guides are easily replaced when the occasion does arise.

No real capital outlay is required to get these benefits because the cost of Martin Plungers and Martin Cages is very much the same as you are now spending for replacements — sometimes less.

All regular or stroke-thru ROD PUMPS and TUBING PUMPS can be equipped with Martin Plungers. Martin Rubber Guide Cages are made in all sizes and styles. Write for our catalog No. 4; also see Composite catalog for 1956-57.

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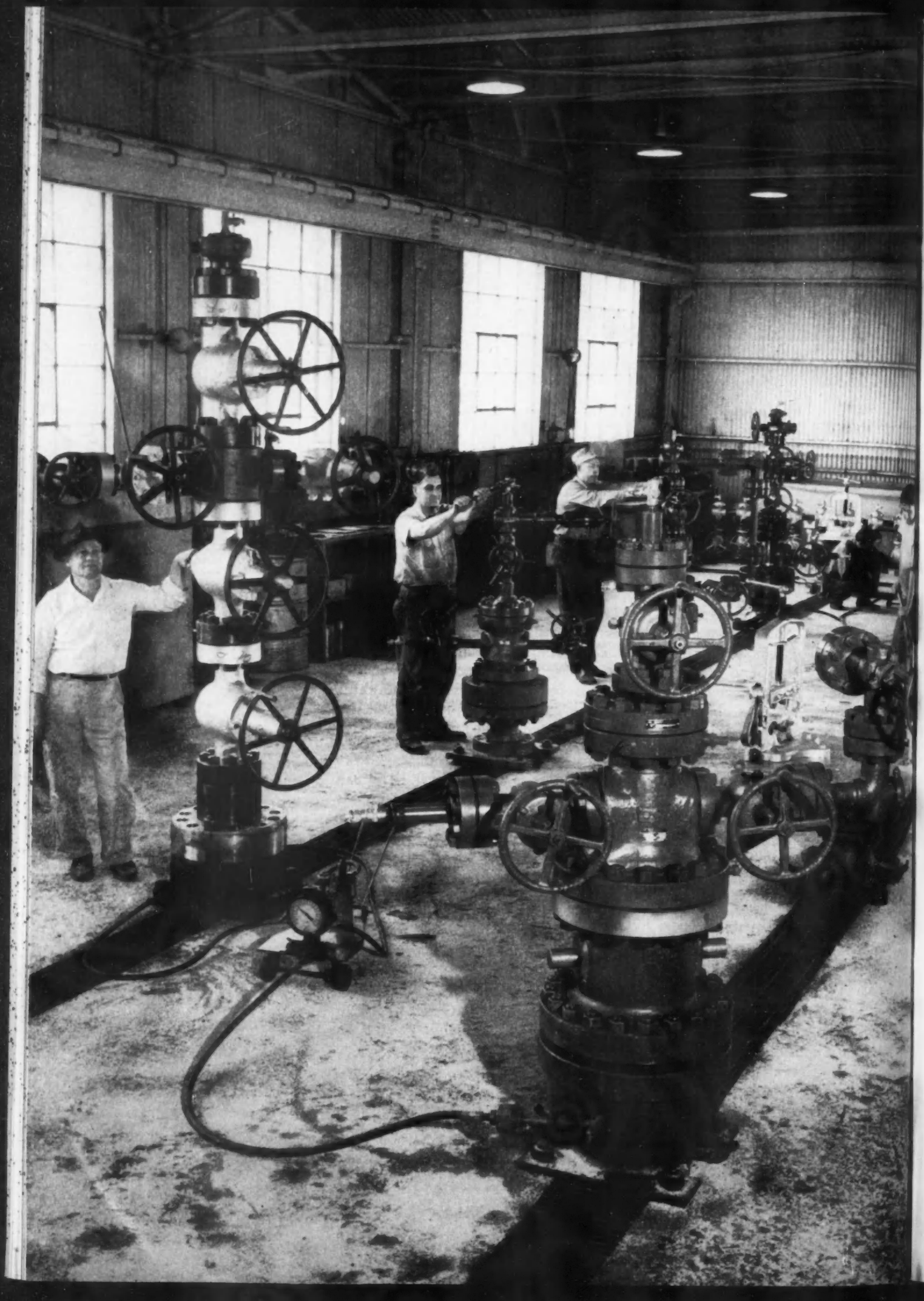

Proved, Then Proved Again

Costly time is lost, disaster invited when equipment fails in the field. Factory-assembled well control equipment must undergo rugged trials before it is exposed to the rigors of field conditions. It must be proven first in the shop to prove of value in the field.

At one time in the history of a certain tribe in Africa, a male didn't become a full-fledged warrior until he single-handedly killed a mature lion with his spear.

Even today in remote parts of the world, male members of tribes and clans must undergo rugged physical trials, sometimes excruciating pain, to prove their worthiness of wearing the mantle of adult responsibility.

Americans believe in testing, too. Of course, our way of life dictates that we place the emphasis on our "warriors" in a different way. But when they produce something—a new frozen food, an automobile, a rifle, a lawnmower, a BB gun or a new type of wellhead equipment—the product undergoes more rugged testing than any Cherokee brave ever encountered.

No Oil Center Tool Company machinist, engineer or field man has ever killed a lion single-handedly with a spear . . . although a few have popped off some wolves in West Texas and a couple of bull 'gators in South Louisiana.

But these men and their equipment run gauntlets all the time.

The gauntlets are problems encountered by companies and individuals who drill for oil and gas.

And one big reason why O-C-T equipment proves its mettle in the field is because the equipment is proven in the shop first.

O-C-T testing facilities in the Houston headquarters plant simulate field conditions.

That's why when you buy O-C-T you buy equipment that has been proven.

Testing is an important part of all-encompassing O-C-T service.

Whether it's a complete 30,000 pound test Tree, a casing or tubing head, flange, choke or gauge, O-C-T has its own gauntlet to prove the product's mettle.

That's why you install O-C-T equipment with an assurance it will work—for it has worked before.

O-C-T tests all the way down the line.

There are tests for new designs.

There are tests for equipment making its debut and for equipment that has been refurbished.

O-C-T is test conscious.

An O-C-T product goes out of the shop prepared and ready for the biggest test—the field test.

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some word of caution should be taken into consideration. First, the recommended practice is to connect the capacitors in the motor line to be switched with the motor, located between the line contactor and the motor but ahead of the overload relay heater elements. This is done to enable the same overload heater elements and standard heater table sizes to be used. Secondly, to avoid dangerous transient torques and overvoltages due to self-excitation, the KVAR capacitor sizes selected should not exceed those listed as corresponding to the various horsepower ratings shown in the application table. These values will improve power factor to 85-95 percent for the load depending upon the initial over-all power factor for the system. Here are the recommended capacitor ratings for switching with Nema Design C, Open, 1200 revolutions per minute, oil well pumping motors.

Motor Horsepower	Capacitor KVAR
5	2
7.5	3
10	4
15	5
20	6
25	8
30	9
40	12

Third, a time lapse, several seconds, should be allowed after switching the motor and capacitor off before personnel touch the capacitor or starter interior in order to allow sufficient time for the capacitor charge to drain off. Otherwise, possible high discharge currents may "spark over." While these currents are not necessarily harmful, accidents could be caused by frightening a man.

Conclusions. A great many leases—even some major projects—are being installed today without due consideration being given to the better protection and operating results to be obtained from these five basic engineering practices. Far too often low first cost becomes the criterion for the equipment to be purchased without due regard for the extra benefits to be gained by a slightly larger expenditure of money. We should remember that in producing oil, an ounce of prevention is certainly worth a barrel of cure. —**The End**

Forecasting for Gas Reservoirs

Continued from Page 198

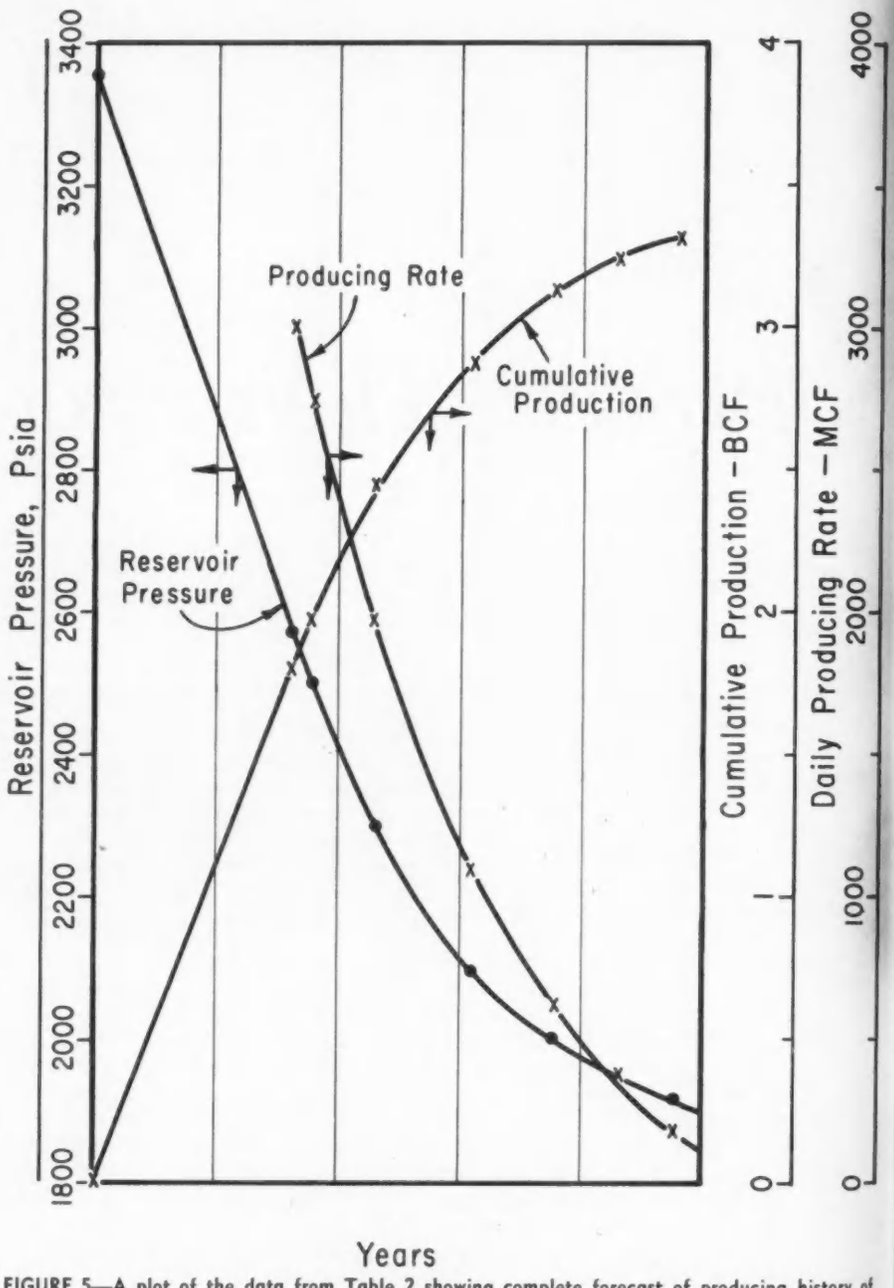

FIGURE 5—A plot of the data from Table 2 showing complete forecast of producing history of the reservoir.

agree to compress the gas (at seller's cost) at some time in the future when deliverability against line pressure has declined to some predetermined level. Before making a production forecast on gas reservoirs, therefore, it is always a good idea to study the gas sales contract involved.

All gas purchase contracts are subordinate to the state regulations as to allowable gas production from a well or field. If the latter are not established at the time a forecast is made, care must be taken to make realistic estimates of the allowables likely to be established so that the constant-rate portion of the history may be correctly forecasted.

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ACKNOWLEDGMENT

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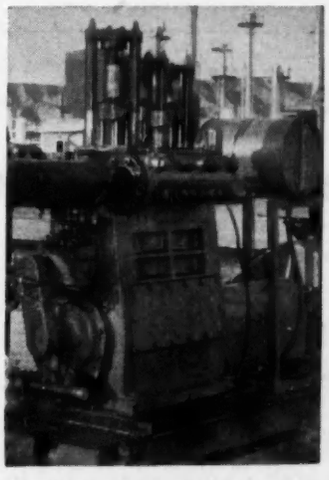

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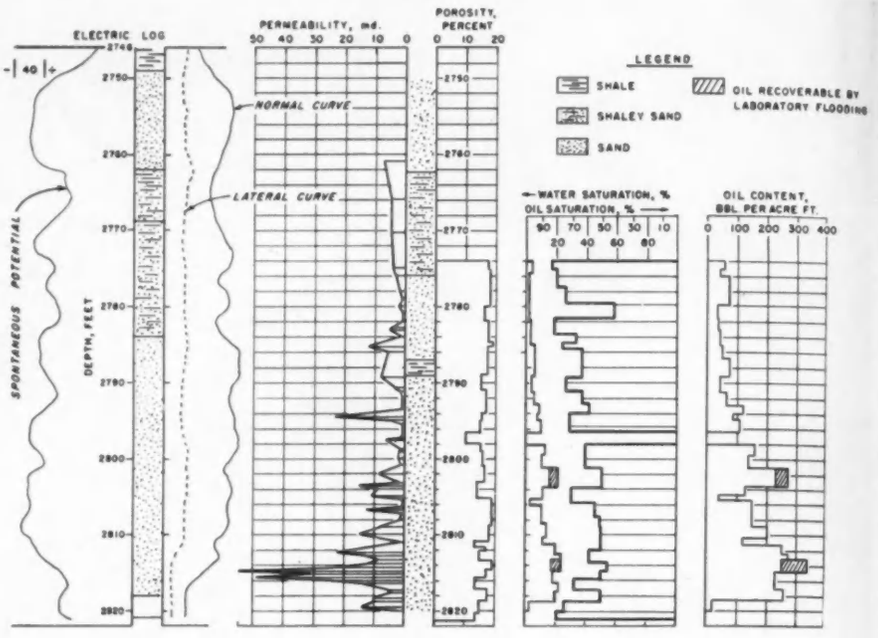


FIGURE 1—(Left) Morrison Producing Company, Fox-Bush project, Butler County.

FIGURE 2—(Top right) A representative electric log and core analysis, Morrison Producing Company, Fox-Bush project, Fox-Bush field, Butler County, Kansas.

Fracturing Shoestring Sands Successfully

Producing and injection wells in shoestring sands benefit from fracturing. Increased injection rates and well productivity result.

FRACTURING A SHOESTRING sand in a water-flood project has proved successful in the Fox-Bush field in Butler County, Kansas. This technique is unique and has not heretofore been attempted in shoestring areas where sands are narrow and erratic, although fracturing has been successful in blanket-type formations. The fracturing technique at Fox-Bush has been utilized to increase water injection rates as well as to increase well productivity.

Morrison Producing Company operates the properties in the Fox-Bush field and pioneered the shoestring sand fracturing method and other operators are studying the results. Prior to fracturing the properties had failed to respond commercially. Since fracturing, both production and water injection rates have been increased and the properties are now operating at a profit.

The properties in the Fox-Bush field in Butler County, Kansas, Figure 1 cover 1980 acres of which 990 were included in the water-flooding project at the end of 1955. The royalty interests have been unitized. Water-flooding operations were begun in 1943 in Sec. 24, T29S, R5E. The project has been developed and expanded sporadically during the ensuing years. The Bartlesville shoestring sand is flooded at an average depth of 2800 feet and has an average thickness of 36 feet. Analyses of cores indicate that the formation had, before flooding, the following average characteristics: Porosity of 16 percent, average permeability, 130 millidarcys, oil saturation 25 percent, and water saturation 44 percent. A representative electric log and a core analysis are shown in Figure 2. Analyses of cores from wells shown in cross-section A-A, Figure 3 indicate that the middle part of the shoestring sand is highly permeable and that the lower part often is water saturated. The delayed drilling of the oil wells and the fracturing of edge producing wells are techniques that have been used successfully on this project and are now followed as regular operating practices.

History Before Flooding. The discovery well in the Fox-Bush field was drilled in 1917 in Sec. 17, T29S, R5E. Oil was produced by primary methods for about six years, after which vacuum was introduced into the field. Several centrally located plants were constructed for processing gas from the wells. The natural gasoline was removed from the gas produced under

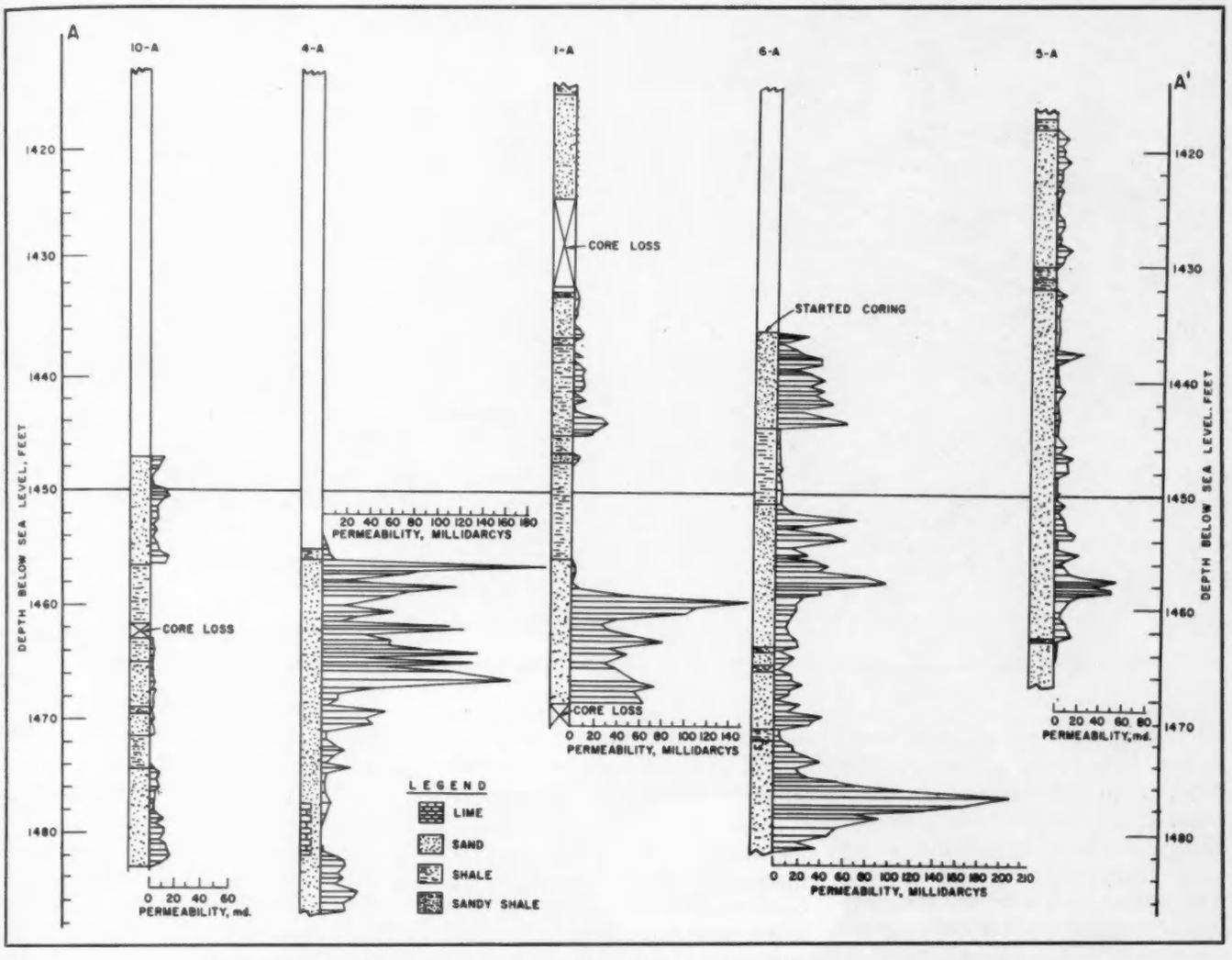


FIGURE 3—Permeabilities of Bartlesville sand in wells in Morrison Oil Company, Fox-Bush projects.

vacuum, and the residue dry gas was used in the field as fuel. Originally the derricks were left over the wells, which were pumped off the beam by individual 20- to 25-horsepower gas engines. By the late 1930's, however, most of the wells were operated from central bandwheel power. When water injection was begun in 1943, most of the oil wells in the field had been abandoned. The pilot flood used some of the original 20- to 25-hp gas engines to pump individual wells, but most of these engines have since been replaced with electric motors. On all of the more recent developments, individual electric pumping units are used exclusively. Data on the annual rates of oil production before flooding are not available, but 5,149,456 barrels of oil was recovered before water injection by primary production methods and by use of vacuum. This is a recovery of about 3700 barrels per acre from the 1395 developed acres.

Completing and Operating Wells. The water-input wells are drilled with rotary equipment into the top of the oil sand. To determine precisely the top of the pay sand, the wells are cored through an overlying shale and into the top of the oil sand. Four and one-half or 5½-inch casing usually is set about one foot into the pay sand and is cemented with 100 sacks of cement. After the cement has hardened, the cement plug and the oil sand are drilled with cable tools. The sand face is washed with water, but if the return water is not clear after thorough washing, 50 to 100 gallons of mud acid are used. The well then is connected to the waterline and the rate at which water can be injected is determined. If the well does not take water at a reasonable rate, or if the rate of injection slows appreciably after the injection of about 300,000 barrels of water, the well is hydraulically fractured, using water and 1500 to 2000 pounds of sand. Water usually is injected into most wells at a rate of 500 to 600 barrels per well per day.

The producing wells are drilled and completed in the same manner as the input wells. If a well does not produce at a satisfactory rate, it is hydraulically fractured, using an average of 2000 pounds of sand and 1500 gallons of lease oil. Oil wells drilled along the edge of the field where the formation is thin or interbedded with shale are hydraulically fractured when completed. Since this method of completion was adopted, more oil has been recovered per well, although the water-oil ratio has been increased. None of the wells are drilled entirely through the sand. Only a few old wells have been reworked and used in the flood pattern. The inactive input wells on the Fox leases will be used later to flood the eastern part of the lease.

Source and Treatment of Water. During the first four years of water injection, an aquifer at a depth of

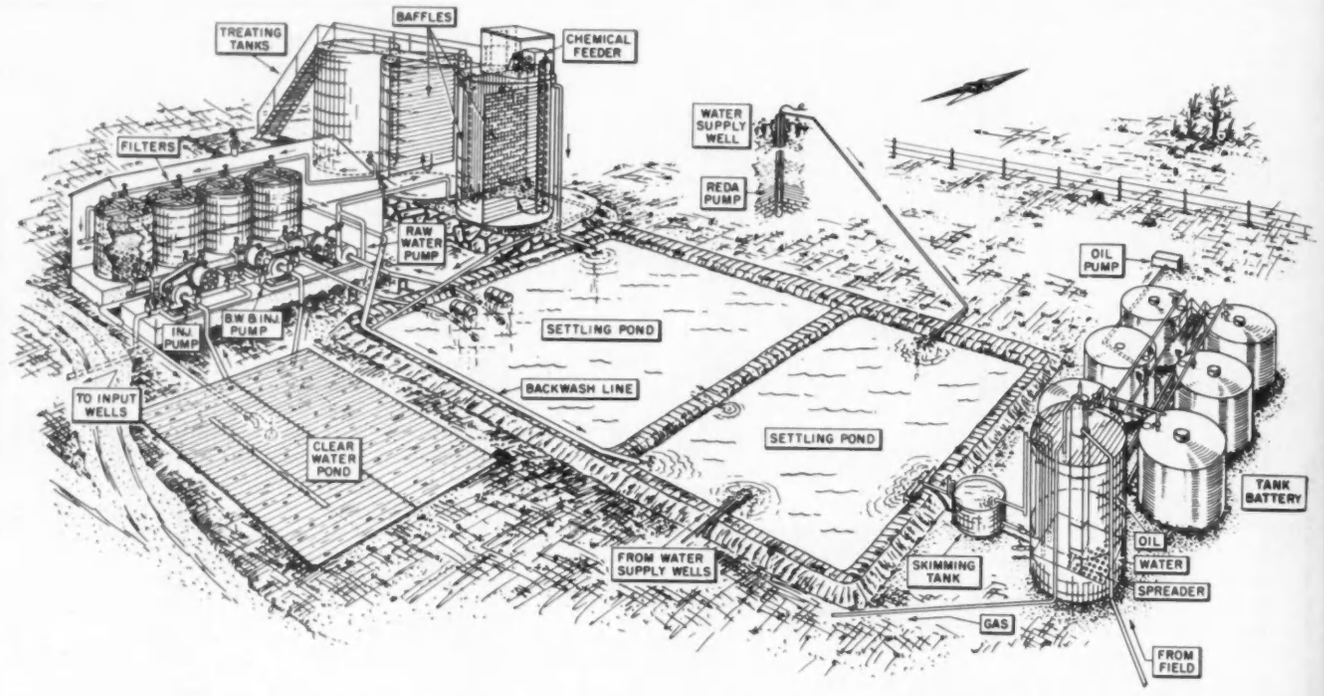


FIGURE 4—Water-treating plant of Morrison Producing Company, Haggert lease, Fox-Bush project, Butler County, Kansas.

300 feet was the only source of brine. In 1947, a well was completed in the Arbuckle limestone formation to supplement this supply. The Arbuckle brine was satisfactory but unnecessary after abandonment of some input wells on the Bush lease and the adoption of new completion and development practices on other leases, reduced the supply water requirements.

Pumping of water from the shallow wells is more economical. The Arbuckle well now is maintained on a standby basis. In 1953, a second plant was constructed and four additional supply wells were completed in the shallow water sand with 7-inch casing set and cemented to the surface. The water-bearing formation which is about 10 feet thick (known locally as the Wreford sandy lime) was acidized with 1000 to 1200 gallons of hydrochloric acid. A three-hp submersible pump in each well forces the water to the surface and thence to a settling pond.

These wells are spaced at wide intervals along the shoestring, each with a daily capacity of 800 to 900 barrels of water. They are used also to supply water for the drilling rigs. Brine produced with oil also is used for flooding. Two water-treating plants serve the project, one on the Haggert lease in Sec. 1, T28S, R5E, and the other on the A. E. Fox lease in Sec. 13, T28S, R5E. The two plants are similar but the Haggert plant is the newest and most modern and will be described in detail.

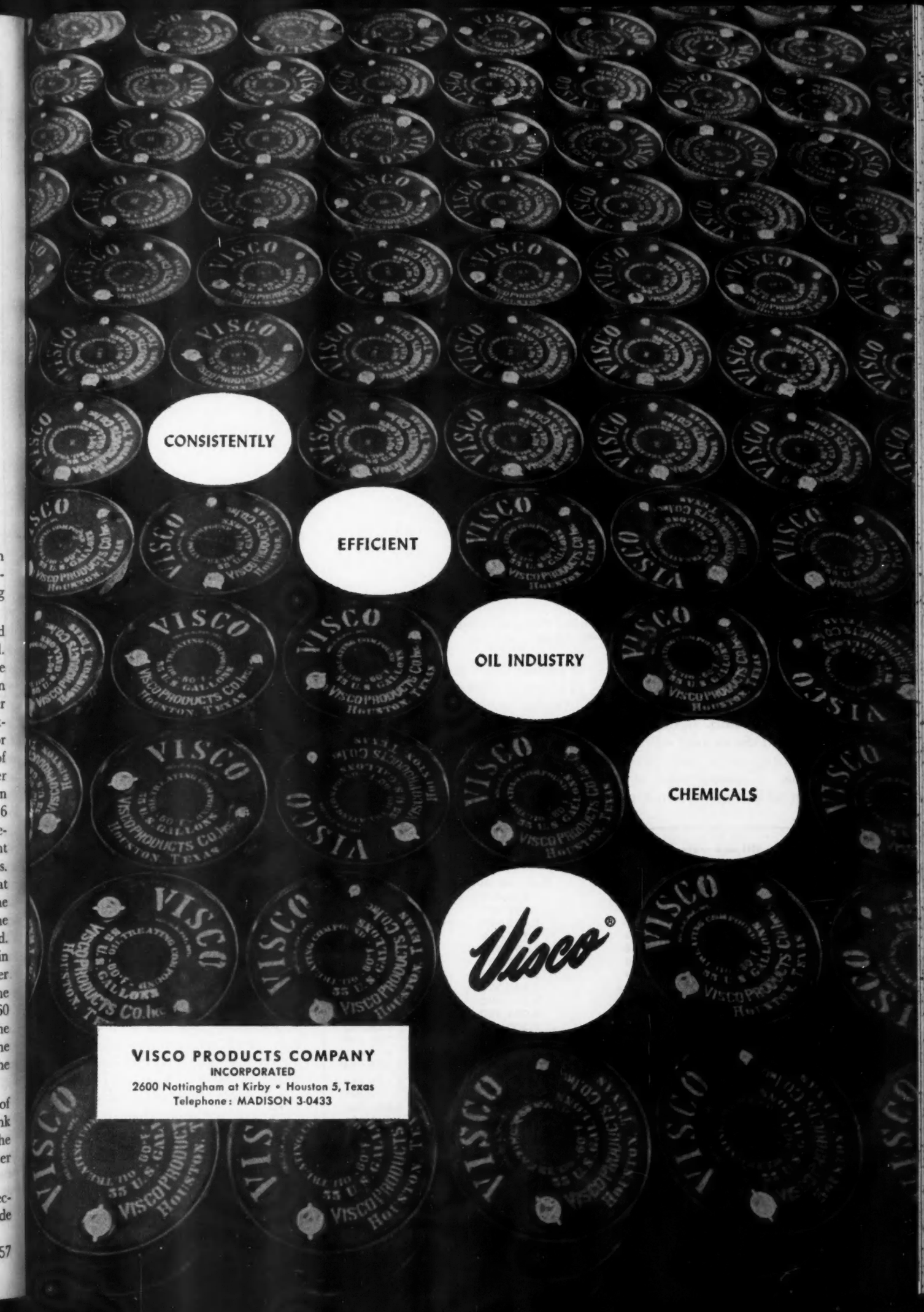
Figure 4 is a pictorial drawing of the Haggert plant. The water from the tank battery is collected in a 100-barrel wooden tank where any oil that might have been carried through the gunbarrel is skimmed off. From the skimming tank the water flows over an aerating platform and falls into the settling pond to be mixed with the water from the supply wells. The earthern settling pond, which is lined with an asphaltic material to prevent seepage is 150 by 85 feet, and is divided by an earthern baffle through which the water flows in two 10-inch conduits. Water in the settling pond enters a 4-inch floating suction line, and a 3- by 4-inch centrifugal pump powered by a 7½-hp electric motor forces it into the first of a series of three wooden, 500-barrel, treating tanks.

The water enters the treating tank at the top of a flume that extends almost to the bottom of the tank. A chemical mixture is added and mixed with the water. The treated water flows over and then under other baffles in the tank before flowing to the second tank. The second tank is provided with a single baffle under which the water passes before rising to overflow into the third tank. The third tank is not equipped with baffles. From it the water flows to four open type rapid-sand filters. Sludge is removed through a line to the settling pond.

The filters are wooden tanks filled with graded gravel and filter sand. Troughs in the form of a cross at the top of each filter provide for the even distribution of the incoming water and for the collection of the backwash water. A perforated collector ring provides for the even flow of water from the bottom of each filter to the clear-water pond, an earthern pit approximately 30 x 30 feet x 6 feet deep. It is asphalt lined to prevent seepage and covered to prevent contamination from dust and debris. Each filter is equipped with a float that regulates the flow of water to the unit and an overflow line to carry the backwash water to the settling pond. Two centrifugal pumps connected in series or "staged" force the water from the clear-water pond into the distribution lines at a pressure of 60 pounds per square inch. However, the piping is arranged to permit one pump to be used for backwashing the filters.

To provide for greater flexibility of operation, the Haggert and Fox tank batteries are interconnected, and the two plants discharge treated water into a main distribution line.

An arrangement of floats and electrodes in the ponds and tanks provide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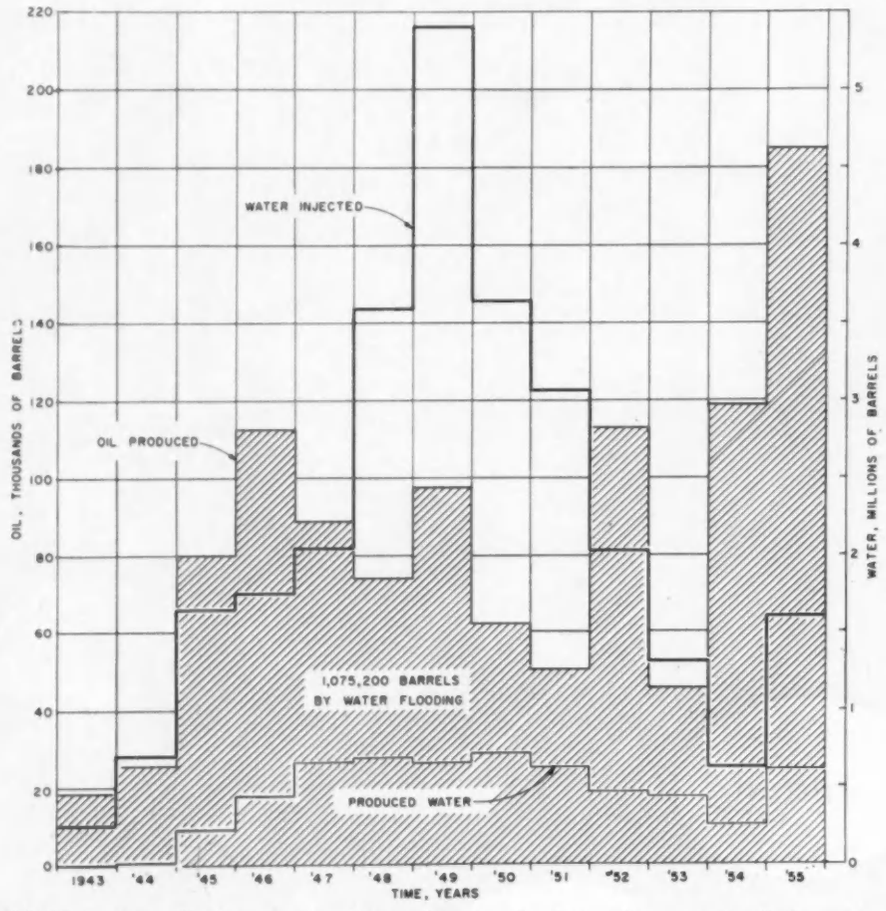

FIGURE 5—Water-flood production history, Morrison Producing Company, Fox-Bush project, Butler County, Kansas.

for the automatic operation of the treating and pumping system.

Results of Flooding. Sporadic development and the delayed drilling of the producing wells have caused irregularities in annual rates of oil production which range from a peak of about 113,000 barrels of oil in 1946 to a low of 46,000 in 1953.

During the first years of flooding the injected water channeled through the bottom of the sand or through the gas sand on top as well as through a very permeable section in the middle of the sand. This resulted in a large water-injected to oil-produced ratio that reached a peak in 1951 when the annual ratio was 61 to 1 and the cumulative ratio increased to 36 to 1. Selective plugging of the bypassing zones with cement and plastic was tried but was unsuccessful. A modification of well-completion practices by cementing off the top gas sand and highly permeable section in the bottom of the sand has aided in decreasing the bypassing of the water.

Also a change in the flood pattern to take advantage of the more permeable zones, by locating the input wells in the middle of the shoestring, has resulted in a better flooding efficiency. During 1954 and 1955, when these modifications were first tried, the annual water-injected to oil-produced ratio declined to 5 to 1 in 1954, and 9 to 1 in 1955, and caused a decrease in the cumulative ratio to 29 to 1 at the end of 1954, and 26 to 1 at the end of 1955. The flooding from the center of the shoestring toward the outside edges appears to be most effective on this project.

The results of water flooding on the Fox-Bush project are shown in Figure 5. Over 1,075,000 barrels have been recovered to date from the 990 acres included in the project. Although many older leases in the southern part of the project have passed their peak rate of production and some have been abandoned (approximately 800 acres had been abandoned by 1953), the project reached a new peak rate of production in 1955 that was more than 50 percent above the earlier year. Even greater production is anticipated for 1956.

Summary of Water-flood Performance

Date	Acres Flooded	Active Input Wells	Active Oil Wells	Oil Recovery, Bbl. per Acre	Cum. Water-Inj.—Oil-Produced Ratio
Dec. 31 1943	14	4	2	1,330	15
Dec. 31, 1944	156	7	7	285	22
Dec. 31, 1945	200	14	13	624	21
Dec. 31, 1946	285	19	13	834	18
Dec. 31, 1947	285	19	13	1,145	20
Dec. 31, 1948	565	30	13	710	25
Dec. 31, 1949	690	33	20	723	31
Dec. 31, 1950	790	33	23	711	34
Dec. 31, 1951	790	33	23	774	36
Dec. 31, 1952	830	33	23	874	33
Dec. 31, 1953	890	37	15	866	33
Dec. 31, 1954	973	7	19	915	29
Dec. 31, 1955	990	13	20	1,086	26

Oil and water produced, water injected by years, bbl.
Morrison Producing Co. Fox-Bush project

Year	Oil Produced	Water Injected	Water Produced
1943[1]	18,621	274,807	608
1944	25,839	707,870	13,925
1945	80,404	1,642,931	231,456
1946	112,792	1,757,418	443,412
1947	88,806	2,059,574	672,883
1948	74,760	3,590,639	693,490
1949	97,767	5,410,479	653,273
1950	62,348	3,650,320	723,650
1951	50,482	3,072,220	630,465
1952	113,321	2,025,320	474,520
1953	45,707	1,300,407	430,740
1954	119,077	627,641	256,187
1955	185,308	1,604,609	624,625
Total	1,075,232	27,724,235	5,849,234

Cumulative production before flooding	5,149,456
Recovery per acre before flooding[2]	3,691
Cumulative production by water-flooding	1,075,232
Recovery per acre (990 acres)	1,086
Cumulative total production to January 1, 1956	6,224,688
Total recovery per acre[2]	4,462
Cumulative water injected to January 1, 1956	27,724,235
Cumulative water produced to January 1, 1956	5,849,234

[1]Annual primary oil-production data not available; water flooding begun.
[2]The oil production by primary method included only 1,395 acres of the Morrison Producing Co. leases. These figures are based on that area.

ACKNOWLEDGMENT

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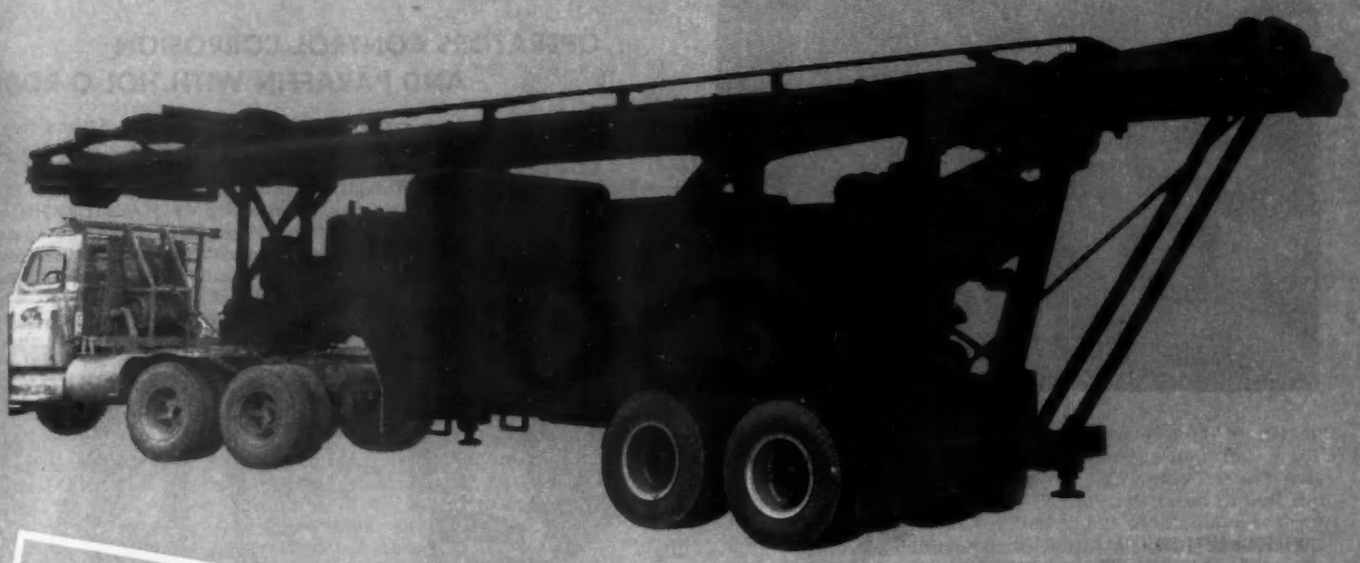

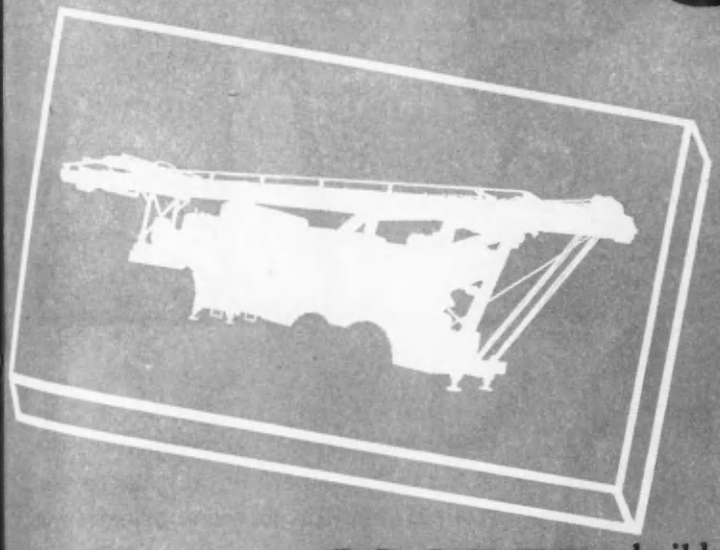

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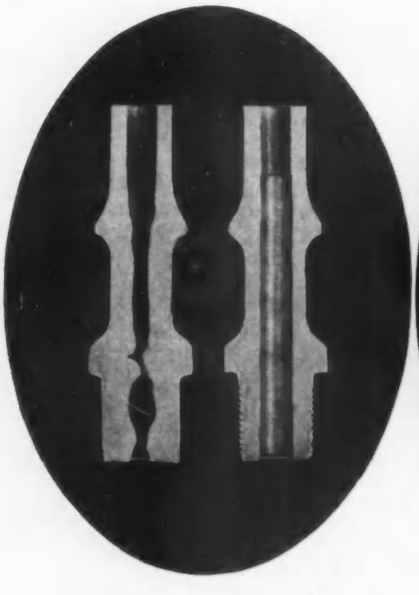
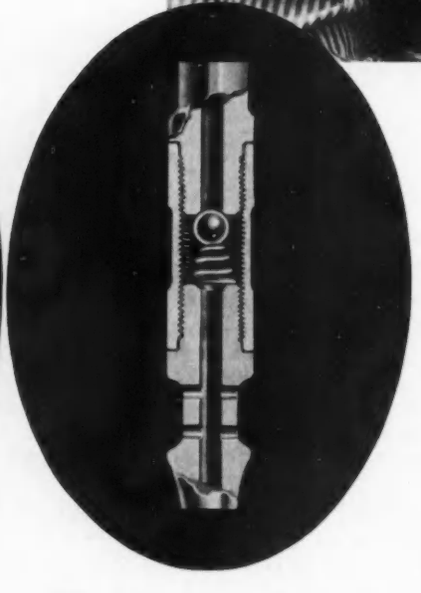
OPERATORS CONTROL CORROSION AND PARAFFIN WITH HOL-O-RODS

Close control of corrosion and paraffin conditions 'way down below is being practiced by the two operators on this page, with the help of Axelson HOL-O-RODS.
At left, Carter Oil Company Production Foreman Bill Dancy is supervising the running in of 1" HOL-O-RODS at J. Detrich #8, Trapp Pool, Kansas. Damage to equipment caused by troublesome conditions is substantially reduced by injecting corrosion inhibitor 2100 feet down through these hollow sucker rods into the reservoir. The same HOL-O-ROD installation is being used at the nearby J. Detrich #5.

PARAFFIN CUTTING. Injection of a paraffin solvent through Axelson HOL-O-RODS is being discussed by (l. to r.) Jim McKenzie, Axelson representative; Ernie Brant, Axelson District Manager; and Marlin Archer, pumper for Carl I. Olsen, producer. Located at Lake Houston, Texas, this well (State Lease Taylor #1) is using an Axelson plunger pump set at 5000 feet, and a complete string of Axelson HOL-O-RODS.



FIRST ONE-PIECE NON-WELDED hollow sucker rod in the field is the Axelson HOL-O-ROD, pictured above in two stages of manufacture. To avoid breakage resulting from the common practice of fabricating rod ends separately and then welding the ends to the rods, Axelson works the rods all in one piece, upsetting the ends, as shown in the left cross-section, and then re-drilling the hollow portion.

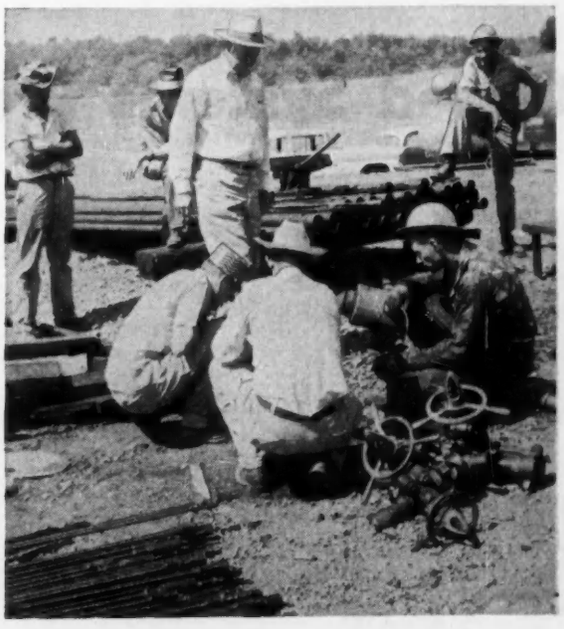


CHECK VALVE to prevent the back flow of well crude through HOL-O-RODS can easily be installed at the lower end of a rod string by using a standard coupling with a spring-loaded ball and seat, as shown in above cutaway drawing. Beyond this check, the injected fluid is ported to the annulus through drilled holes in a HOL-O-ROD Pony Rod. Axelson representatives can supply details.

AXELSON HOL-O-RODS were developed for use in hot oil treatment of oil wells to control paraffin, for chemical injection in corrosion control, for diluent injection to aid in the production of extremely viscous crudes, and for treating two-zone pumping wells.

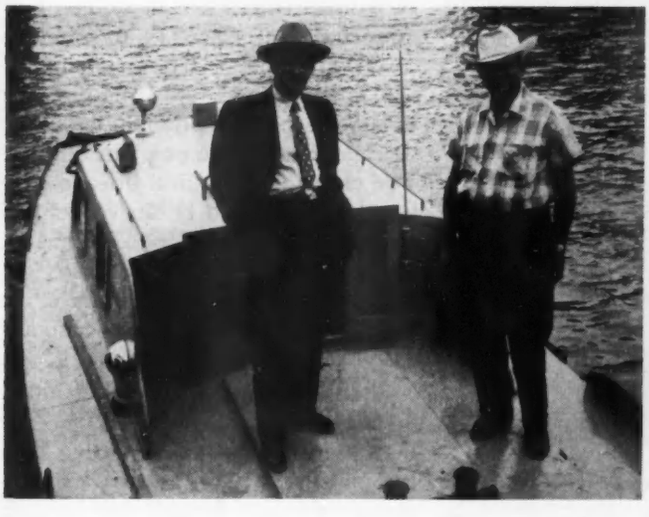
These applications have created another use for HOL-O-RODS: a means of determining bottomhole pressures by application of pressure bombs directly at the surface of the well. Still other uses are constantly being found by men in direct contact with producing problems.

PICTORIAL

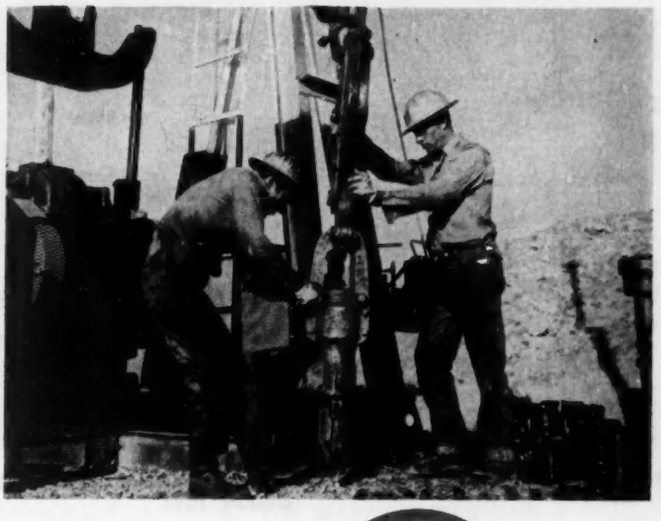


QUICK FRAC. Shown supervising their first "River Frac" in Osage County, Oklahoma, are two district production superintendents for National Associated Petroleum Company—Bud Shewmaker (standing) and Pete Clark Jr. (kneeling with cap). It took only 38 minutes to frac the formation at 2500 feet with 1562 bbls. of sand, water, and mud acid. An Axelson 2 x 1½ x 10' 2" Sure-Seal Pump with double Axloy valves and a 44" chrome-plated grooved plunger produces this well (Rodeo Anticline #5-6). These pumps are standard equipment for most wells in the Osage. The sucker rods at lower left are Axelson #60 ⅝".

OLD FRIENDS. On board the "Gulf Pride" at Caddo Lake, Louisiana, are two longtime friends: Cleon Worley, Axelson District Manager and Axelson employee of 32 years, and M. V. Daniels, Assistant Area Superintendent for Gulf Refining Company. Daniels has served Gulf for more than 27 years in this territory. In this time he has used virtually every kind of pump Axelson has ever made. His wells range in depth from 900 to 6300 feet, and hole conditions vary from "problem children to little angels."



"DO-IT-YOURSELF." The Texas Company's #11 at Black Mountain, Wyoming, was losing production. The Axelson Sure-Seal 2" bore Rod Pump (API, RWT type) was pulled and checked out O.K. The crew wanted to pull the tubing wet to check it for leaks, but didn't have a drop valve. They made one out of the Axelson cup hold-down, and it did the job. Pictured pulling the well are two members of Dick's Well Service out of Powell, Wyoming (l. to r.): Clark Rook and Joe Mosebar.



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Closed Systems Protect Flood Water

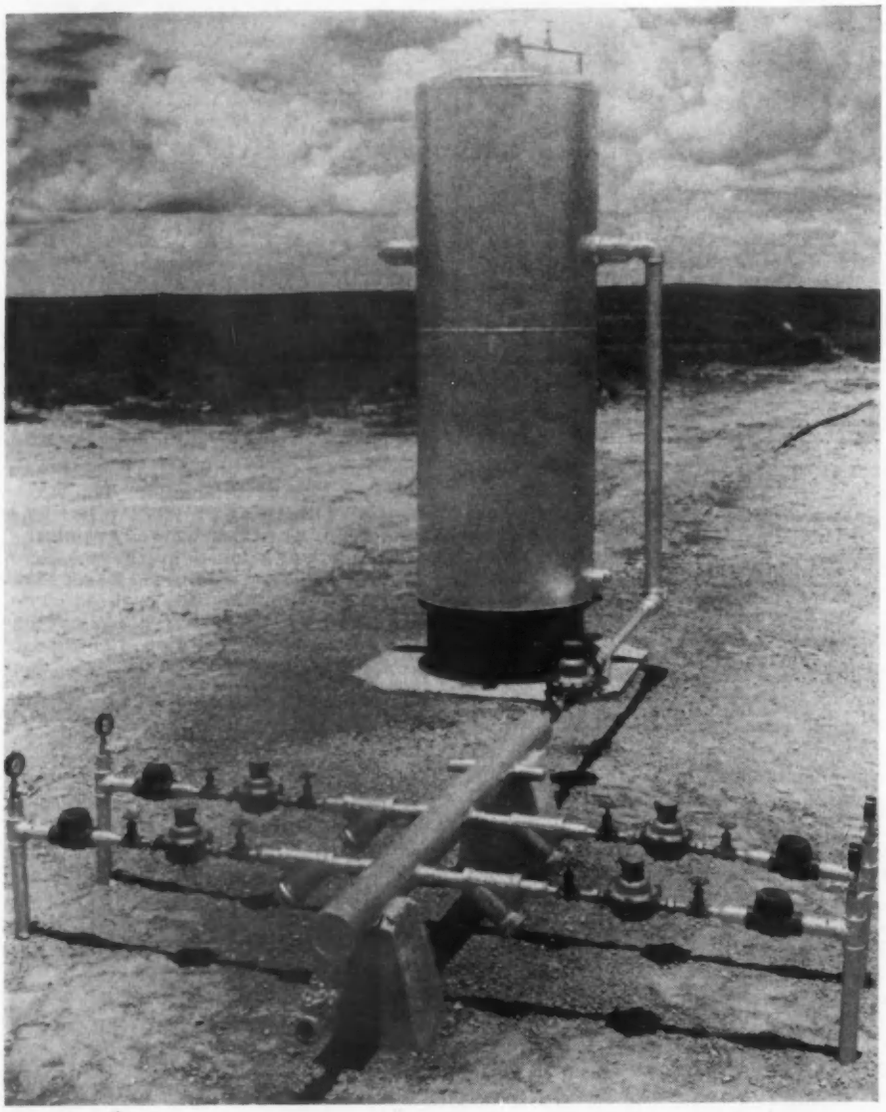


FIGURE 1—Type of vessel used as gas separator and sand trap in small capacity low injection pressure flood.

By L. E. SHARP
Shell Oil Company
Corpus Christi, Texas

WATER-FLOOD OPERATORS in several fields in Duval County, Texas, enjoy at least one advantage not often found in other locations—a large supply of underground water that is compatible without treatment with water found in most of the oil producing zones. Water from the Cole sand is available in many locations at rates as high as 4000 barrels per day from pumping fluid levels of 600 feet to 1000 feet. Complicated water treating plants are not necessary, as proved by the fact that receptivity of injection wells in this locality remains constant over comparatively long periods.

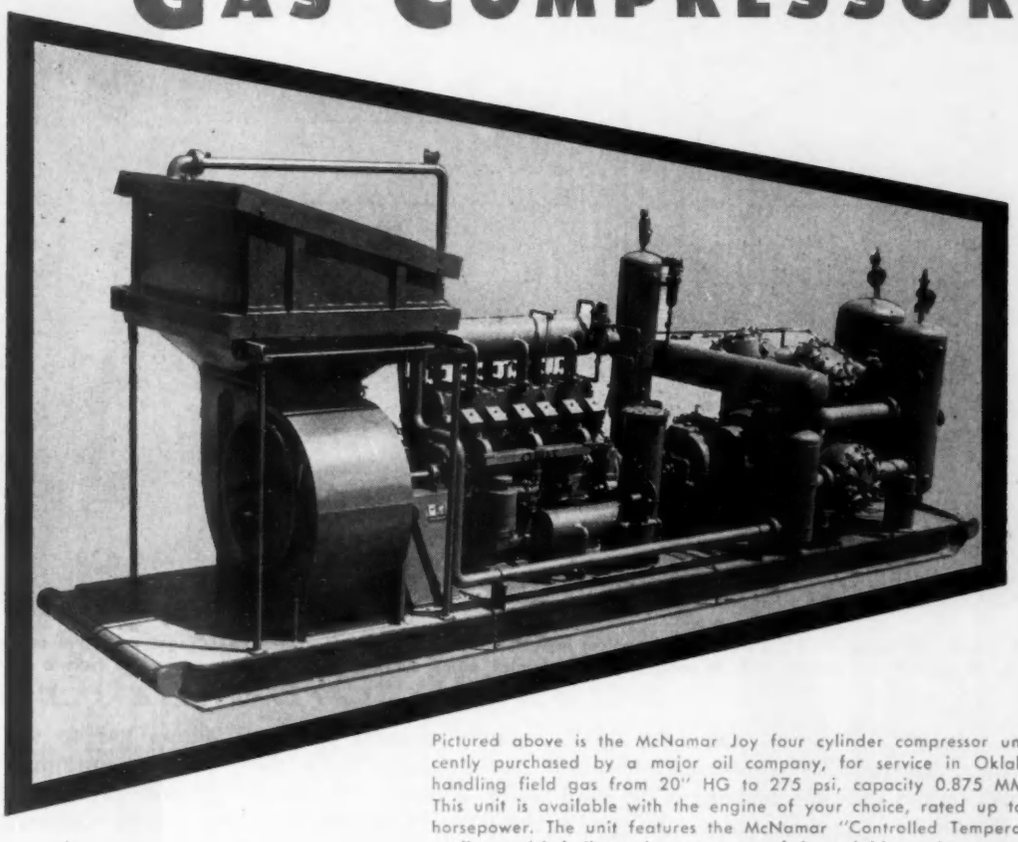
The principal pitfall to avoid is to keep flood water free of oxygen contamination in order (1) to minimize corrosion of the injection system, and (2) prevent plugging of the injection well bores by the products of corrosion, i.e., iron oxide or plain old rust. The closed or pressured injection system has proved to be an economical and satisfactory method to attain these ends. The form that such systems may take is governed almost entirely by the injection pressure and daily volume required.

Shell Oil Company has installed during the past three years two systems which are representative of a comparatively small capacity low injection pressure system and a large capacity, medium pressure system.

Shell-Duval Ranch Company Flood. This small capacity, low injection pressure flood is located on the west side of the North Government Wells field and consists of 10 injection wells and 9 producers in the North Government Wells sand. Maximum desired injection rate per injection well was determined from reservoir studies to be 200 bpd and the pilot tests indicated this volume could be injected at surface pressures from 0 to 100 pounds per square inch. Accordingly, a system capable of injecting 2000 bpd at 150 psi or less was installed.

Here are two examples of how closed or pressure injection systems were effectively and economically applied to specific water-flood operations. The requirements, equipment, problems and solutions of a small capacity, low injection pressure flood and a high capacity, medium injection pressure system are discussed.

McNAMAR-JOY
GAS COMPRESSORS



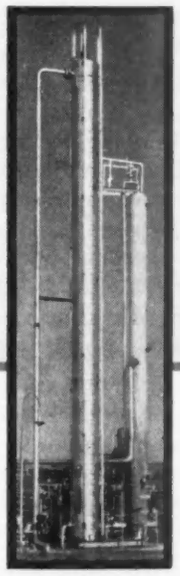
Pictured above is the McNamar Joy four cylinder compressor unit recently purchased by a major oil company, for service in Oklahoma, handling field gas from 20" HG to 275 psi, capacity 0.875 MMCED. This unit is available with the engine of your choice, rated up to 400 horsepower. The unit features the McNamar "Controlled Temperature" cooling and is built to give you years of dependable service.

McNamar Joy-Gas Compressor units are available in one, two or four cylinder models. The four cylinder unit is rated up to 400 horsepower with one, two, three or four stages of compression, developing pressures up to 2,000 psi. The overall weight of this unit is 45,000 pounds.

Single cylinder, single stage units are rated to 100 horsepower. The two cylinder, single or two stage units are rated to 200 horsepower.

The McNamar-Joy unit is complete with rugged Joy compressor, gear reducer or belt drive, engine, cooling system, scrubbers, piping and safety controls mounted on a single structural steel skid.

The unit is extremely portable and can be moved on a tandem semi-trailer without disassembling. The arrangement of the equipment allows easy access to all parts for low maintenance costs.



McNamar Portable GASOLINE PLANT

The McNamar portable gasoline plant is designed for flexible application and automatic operation. Simplicity of design assures dependable operation and low maintenance costs.

The McNamar-Joy Compressor Unit is low in cost and is available on purchase, rental, or rental purchase option basis.

Call, write or wire McNamar Compressor Division for further information.

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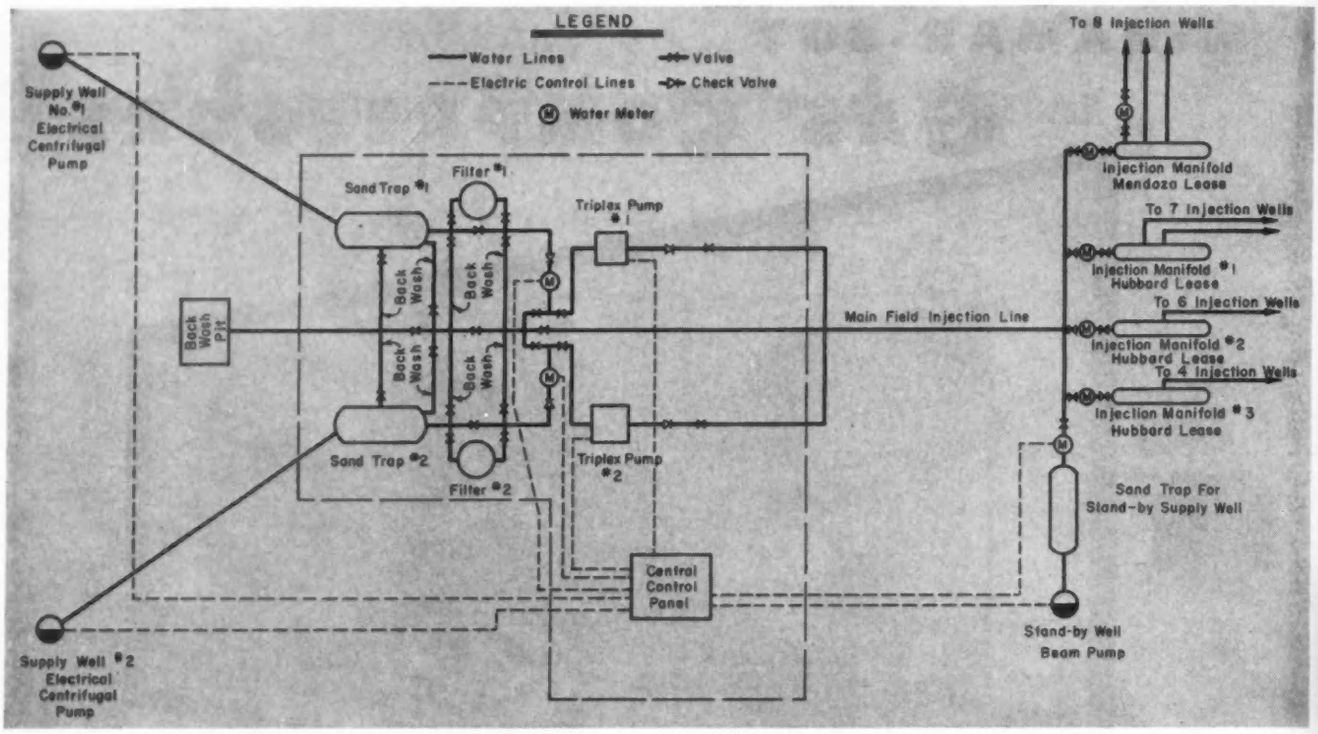


FIGURE 2—A schematic layout of a high capacity, medium injection pressure flood. Electrical centrifugal pumps in supply wells 1 and 2 maintain 20 to 80 pounds per square inch on sand traps and triplex pump suction. All pumps are controlled from a central control panel.

In order to reduce installation and operating costs, the injection system surface power pumps were eliminated from the design by combining the function of lifting water and supplying injection pressure in the beam operated supply well pumps. To accomplish this, it was only necessary to provide some additional capacity in the pumping equipment to overcome the back pressure at the well caused by surface injection pressure at the input wells. Based on a maximum of 100 psi at the injection wells and an estimated 50 psi average friction loss in lines, the total back pressure of 150 psi was equivalent to approximately 300 feet of additional lift on the supply well equipment. A good stuffing box is required at the supply well to hold back pressure due to injection. To provide flexibility and continuity of operation, two supply wells were completed and equipped to pump from 1000 feet as follows:

Pump—3¾" bore TSL
Tubing—4" regular
Rods—⅞"
Pumping Unit—54" stroke, 114,000 in. lb. torque rating driven by single cylinder gas engine
Maximum Capacity—1300 bpd each.

Each supply well produces into a 125-psi vessel which acts as a sand trap and gas separator to take out the small amounts of sand and incombustible gas produced with the Cole sand water. Figure 1 illustrates the type of vessel used for this purpose. The bottom is equipped with jetting nozzles for removing accumulated sand and a gas vent trap allows gas to vent from the vessel while maintaining the required injection pressure. An injection well manifold incorporating a master meter, individual well meters, strainers, checks, flow regulating valves and pressure gauges, all 125 psi test material, is also shown.

Normally each supply well produces 900-1100 bpd and injection well pressures range from 0 to 60 psi at the manifold. A 3-inch line, approximately one-half mile long, connects the two supply systems, but is used only when one supply system is shut down for repairs. Under this condition pump speed on the working system is increased, and approximately 75 percent of normal capacity can be maintained at all injection wells.

During the past two years this system has been in operation, very few deficiencies have developed. Abnormal sucker rod box wear has become apparent and is being corrected by installation of hard rubber guides. Small amounts of sand began to carry over the sand traps when a corrosion inhibitor was first injected at the supply wells. This caused stopping of the injection well meters and was corrected by reducing the chemical injection rate to the minimum needed for protection. Surprisingly,

About the Author

L. E. SHARP is a division mechanical engineer for the Shell Oil Company at Corpus Christi, Texas. A native of Kansas, he graduated from the University of Kansas in 1932 with a B.S. degree in electrical engineering. He joined Shell in 1935 as a roustabout trainee at McPherson, Kansas. Since then he has served in various capacities in the mechanical engineering sections throughout Kansas, Illinois, Oklahoma and Texas.

to avoid wet jobs

specify

MODEL 63

oilmaster

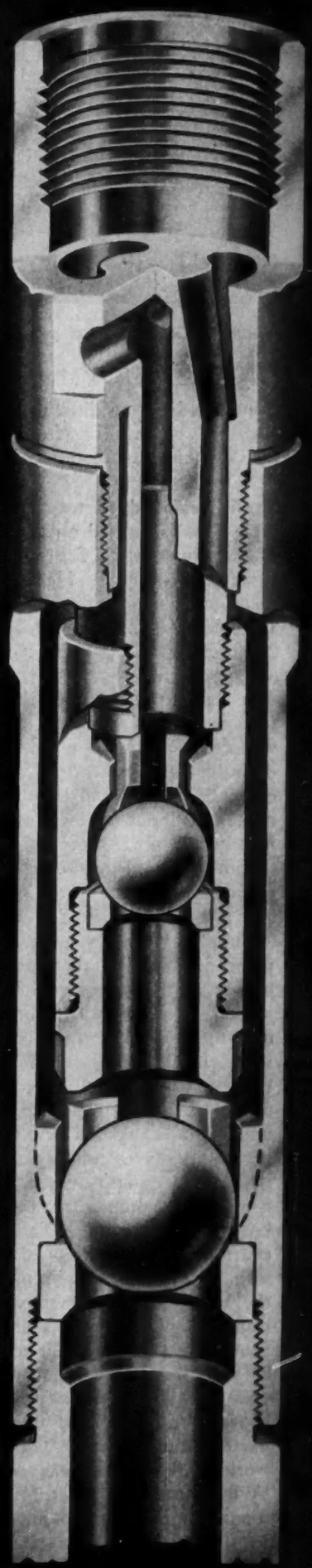
BOTTOM DISCHARGE VALVES

Wet jobs are caused by a pump that is stuck so tightly in the tubing string that it cannot be unseated with the sucker rods. The sticking is most commonly caused by sand settling around the pump barrel above the hold-down. The worst hazard occurs in a stationary barrel bottom anchor pump, where the sand can fill in all the way to the top of the pump.

It has long been known that a bottom discharge valve would keep the area between the pump and tubing free of sand by discharging a portion of the produced fluid at the hold-down. As long as the upward velocity of the fluid exceeds the settling rate of the sand, the annulus remains clean.

Prior to the introduction of the Oilmaster Model 63, bottom discharge valves have not been as dependable a unit as the other components of the pump. Still, they were in common use by operators who preferred to pull a pump prematurely if necessary, rather than risk pulling a string wet.

The Model 63 represents an entirely new approach to the pump valve design problem, and has overcome the weaknesses that previously existed. Numerous improvements have been made that can best be appreciated by a demonstration. Call your Oilmaster representative and ask him to bring out a Model 63 on his next call, or better, ask him to insure you against wet jobs by having him install them on all your stationary barrel bottom anchor or Multiple Tube Fluid Packed Pumps. Try them on long stroke pumps too, to eliminate the need of a top seal element.



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oilmaster PUMPS FOREMOST IN THE INDUSTRY

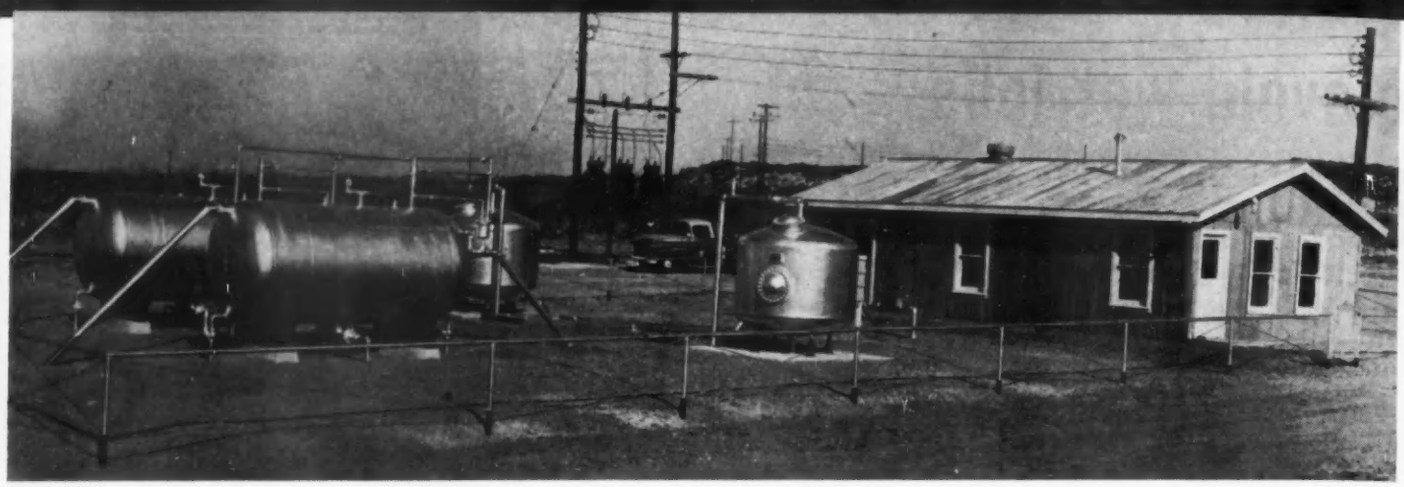


FIGURE 3—General view of pump station showing separator-sandtraps and sand filters. Transformer bank shown supplies triplex pumps only. Electrical centrifugals are supplied from banks located at well site.

there has been no difficulty with the stuffing box resulting from the surface injection back pressure required.

Shell-Hubberd-Mendoza Flood. This flood is located on the east side of the Loma Novia field, and is representative of the high capacity, medium injection pressure systems. It consists of 25 injection wells and 25 producers in the Loma Novia sand at approximately 2750 feet. Reservoir conditions indicated that an injection rate of 300 bpd per input well would probably be the maximum desirable and subsequent tests indicated this rate could be obtained at maximum input pressures of approximately 500 psi. Accordingly, a plant capable of supplying 8000 bpd at 600 psi was installed.

Supply Well Equipment. For a plant of this size, the use of beam pumps as the source of lift and injection pressure was found to be uneconomical because six supply wells would have been required, three of which would have had to be drilled. In order to insure flexibility and reliability of delivery, three supply wells were completed, two of which are equipped with electrical centrifugal pumps, and one with a beam operated pump. The electrical centrifugal pump equipped wells furnish the normal requirements, and the beam well is normally used for standby or emergency. The electrical centrifugal pumps are 40 horsepower, 23 stage, capable of delivering up to 4000 bpd with 650 foot lift and zero pressure into the sand traps located at the pump station. The probable working fluid level was determined by fluid level drawdown tests using a temporary beam pump, and design of the electrical centrifugal pumps was based on these tests. The standby beam pumped well produces into a 600 psi sand trap located near the well and thence directly into the main field water injection supply line. This well has furnished 800-1000 bpd during the past six months when only a few injection wells have been operated. It may also be used in conjunction with one electrical centrifugal pump whenever a total daily capacity of 4000 to 5000 barrels is required in the operation.

Pump Station and Power Supply. Figure 2 shows a schematic layout of the system and pump station, and Figures 3 and 4 show outside and inside views of the pump station. Normally, each electrical centrifugal pump feeds through its own sand trap and filter to the suction of an electrically driven triplex 50-hp pump. The piping arrangement provides for jetting sand from the traps and for backwashing the filters and, in addition, provides that either electrical centrifugal pump can be switched to feed either power pump. Each power pump is sized and the belt drive ratio has been selected to deliver approximately 3700 bpd. Thus, each electrical centrifugal pump, when held down to this decreased output, will create a pressure varying from 25 to 80 psi at the triplex suction, depending on the fluid level in the supply well, condition of the filters, and other factors. It is significant to note that positive pressure on the triplex pumps, filters and traps results in unusually smooth operation and prevents any possibility of air contacting the water supply and creating corrosion and well plugging problems.

It would have been possible to select electrical centrifugal pump equipment capable of lifting the supply water and also putting up the 600 psi maximum desired surface

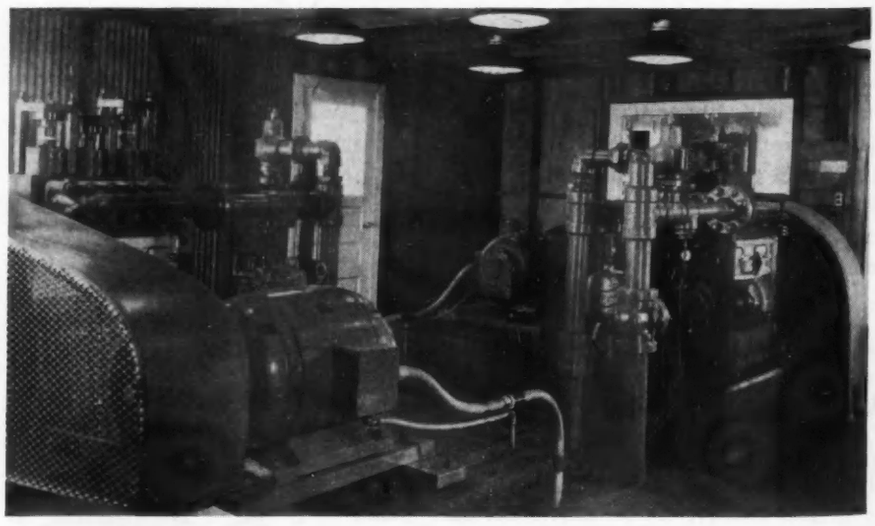
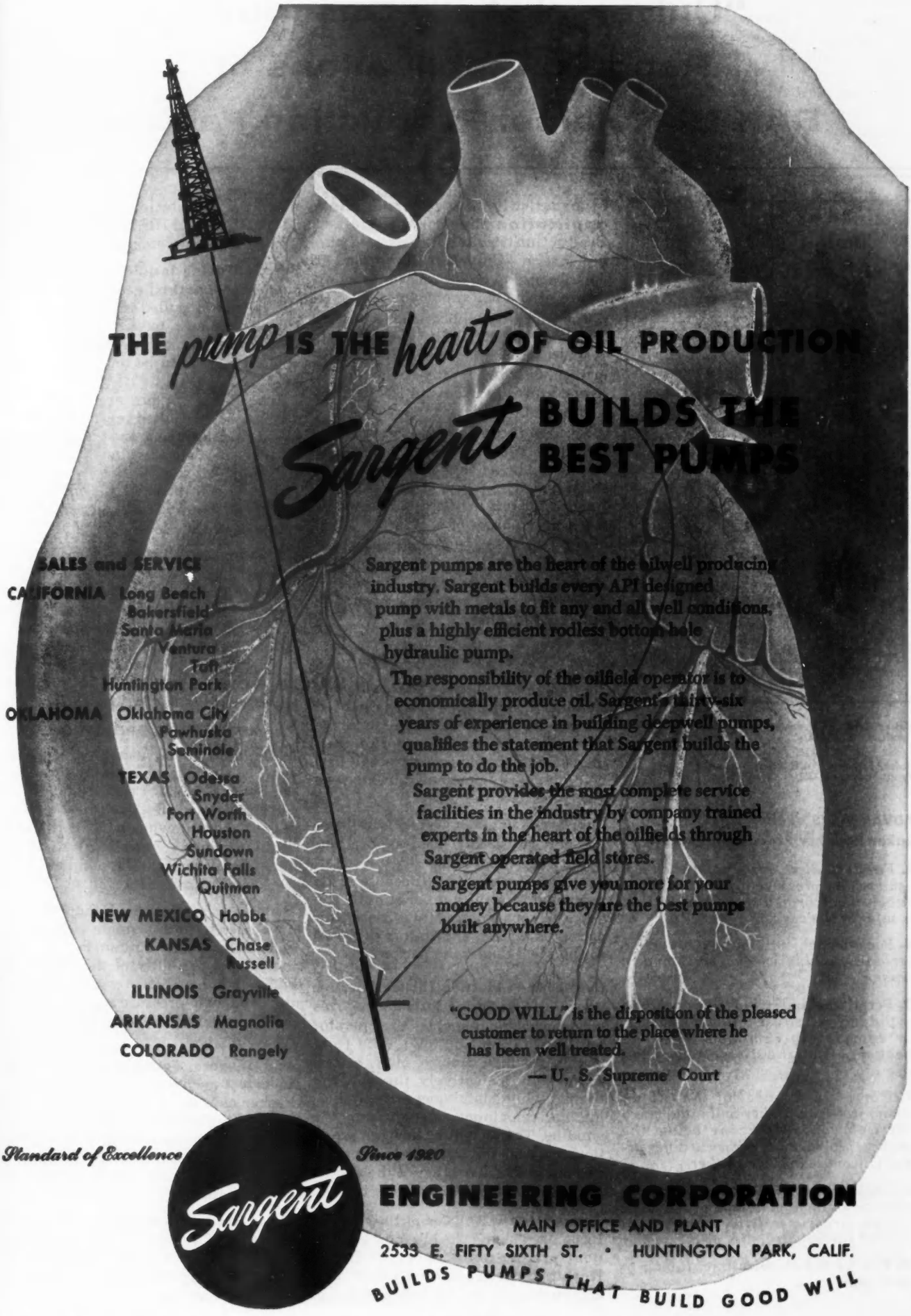


FIGURE 4—Interior view of pump room. Note safety float switch on suction riser.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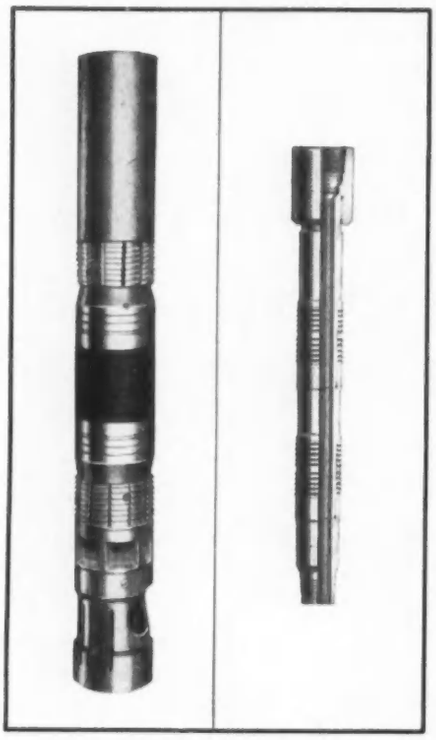
"Universal" Aptly Describes Range of Applications of BAKER Retainer Production Packer



Baker Retainer Production Packer
Product No. 415-D

Baker Locator Tubing Seal Assembly
Product No. 442-E2

ADVANTAGES of the Baker Retainer Production Packer:

1. *Forms positive, leak-proof pack-off against any pressure differential from either above or below the packer that is safe for the casing.*

2. *Pack-off achieved without excessive set-down tubing weight, or tubing in tension.*

3. *Permits tubing string to be anchored to the packer, released from the packer, or completely removed from the packer, all at the discretion of the operator.*

4. *Complete removal of the tubing string from the packer will not disturb the isolation of the zone below the packer, provided the pressure differential is from below the packer.*

5. *Pack-off remains leak-proof under conditions of high temperature, even under pressure differentials that exceed the safety limits of the casing.*

6. *Can be set on wire line, tubing or drill pipe.*

In practically every production application the Baker Retainer Production Packer has earned the designation "Universal" Type; and it appears also to be the answer to many future production problems.

The range of applications is further broadened by its ability to hold high pressures from above or below—at record or shallow depths—even under temperatures in excess of 300 degrees Fahrenheit.

Because it can also be used successfully as a squeeze tool, it is ideal for testing, acidizing, formation fracturing, squeeze cementing, and other operations required in the completion or work-over phases of a well.

The following actual field records of general production, as well as supplemental applications of this "Universal" Type Packer may indicate a solution to your well problems:

PRODUCTION APPLICATIONS

Single-Zone Production—More Baker Retainer Production Packers are used for single-zone production than for any other application—proof of their increasing and widespread usage in a field previously dominated by retrievable type packers.

Dual-Zone, Single-Packer Application—The majority of dual-zone applications of the Baker Packer are single-packer, dual-zone installations. Because of its remarkable ability to maintain the absolute separation of two zones, this packer is widely known and accepted as the ideal dual-zone packer.

Dual-Zone Production (Baker Selective Hook-Up), Two-Packer Installation—This efficient hook-up enables the operator to produce (pump or flow), treat (formation fracture, acidize, etc.), or test either zone selectively through the tubing, while simultaneously producing the remaining zone through the annulus. The switch in flow, or selection of a zone for treatment, is accomplished at the discretion of the operator, using an instrument line.

Permanent-Type Well Completions—Long recognized as the world's most permanent production packer, the Baker Retainer Production Packer was accepted early in the development of this new completion idea as OUTSTANDINGLY FIRST for Permanent-Type Well Completions.

Parallel Tubing Installations—When a *single* packer is used, each tubing string can be run or pulled independently of the other, and by using a special Anchor and a Latching Sub, the short string can readily be anchored to the long string.

When *two* packers are used, each string is run or pulled separately, however, the long string must be *run* first, and the short string *pulled* first. Either the single-packer or the two-packer installation features a full opening to the lower zone for use of all permanent completion-type tools.

Off-Shore Installations—The Baker Packer is used in conjunction with a storm choke to prevent loss of production due to accidental damage to surface connections of off-shore installations. Permanence, plus the ability of the packer to hold mud weight above the packer are additional factors that recommend its use in this application.

SUPPLEMENTAL APPLICATIONS

In addition to its use in practically every type of production application, the Baker Retainer Production Packer can also be used effectively as a squeeze tool in the following wide variety of "Supplemental" applications that might be required in the completion or work-over phases of a well:

Testing—As many as ten Baker Packers have been used in a single well for an efficient, complete bottom-to-top testing program. Ability of the packer to withstand reverse in pressure differential from high-pressure acid squeeze to swabbing enhances its use as a successful testing tool.

Acid Squeeze, Formation Fracture, or Squeeze Cementing—Use of the Baker Packer as a squeeze tool in either the initial completion or during subsequent work-over is widespread, due to elimination of the unnecessary additional expense of running a separate squeeze or testing tool.

Water Flood or Gas Injection—The permanence of the Baker Retainer Production Packer, plus the advantage of a free tubing string, make it a superior packer for secondary recovery instal-

(Advertisement)

lations. The packer has also been used in dual-zone wells where one zone is produced, with simultaneous injection into the other.

Isolation of Annulus—The Baker Packer is corrosion resistant. This feature, plus the fact that the packer permits removal of the production string without disturbing the isolation of the zone below the packer (pressure differential must be from *below* the packer) make it an ideal packer for use in corrosive areas where protection of the casing above the producing zone is of great importance.

Bridge Plug, Temporary or Permanent—The Baker Packer acts as a one-way bridge plug whenever the tubing is removed from the well, provided the pressure differential is from below the packer. It can easily be converted to a temporary two-way casing bridge plug or a permanent bridge plug.

POPULAR APPLICATIONS OF: the Baker "Universal" Type Retainer Production Packer

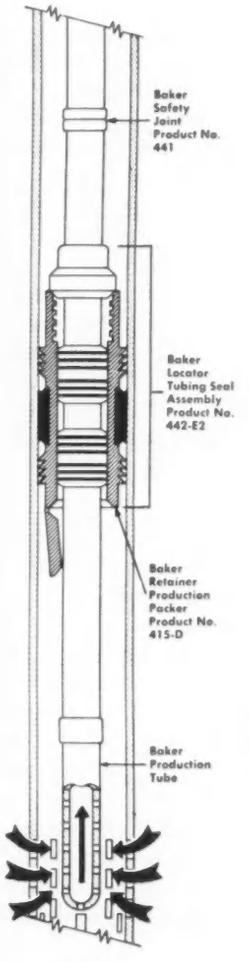

Baker Safety Joint Product No. 441
Baker Locator Tubing Seal Assembly Product No. 442-E2
Baker Retainer Production Packer Product No. 415-D
Baker Production Tube

Fig. 1

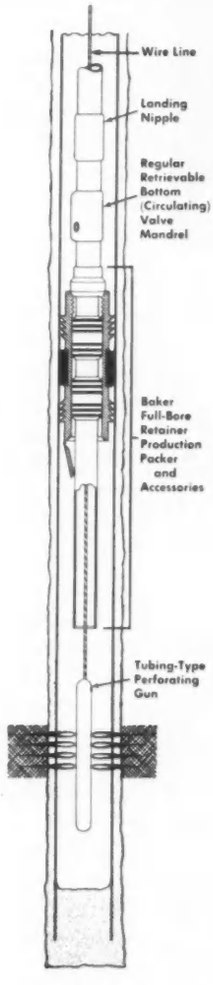

Wire Line
Landing Nipple
Regular Retrievable Bottom (Circulating) Valve Mandrel
Baker Full-Bore Retainer Production Packer and Accessories
Tubing-Type Perforating Gun

Fig. 2

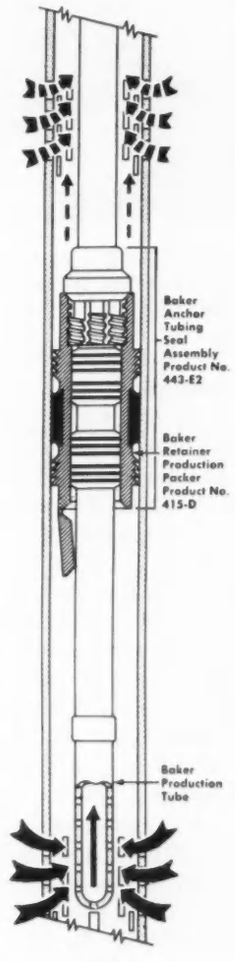

Baker Anchor Tubing Seal Assembly Product No. 443-E2
Baker Retainer Production Packer Product No. 415-D
Baker Production Tube

Fig. 3

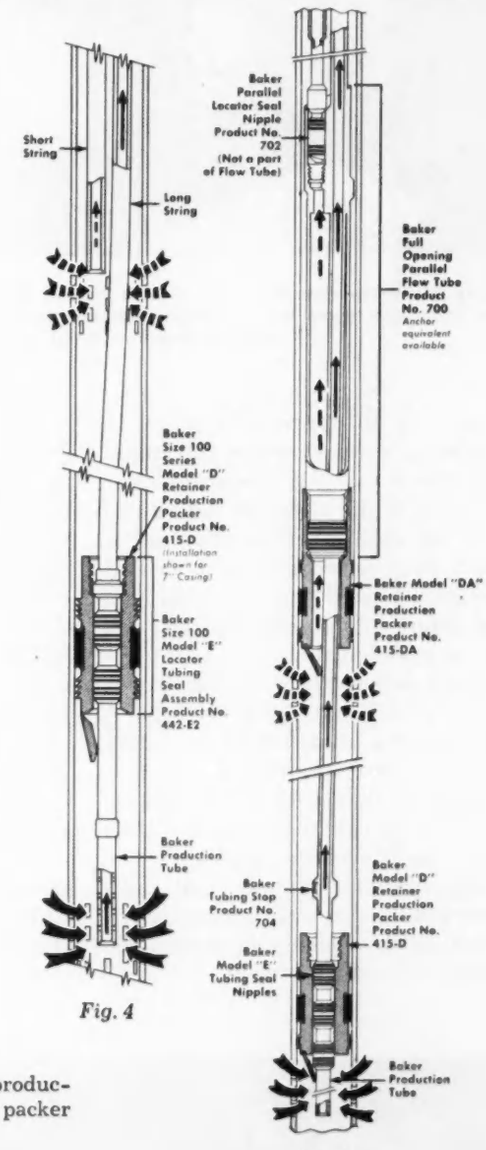

Short String
Long String
Baker Parallel Locator Seal Nipple Product No. 702 (Not a part of Flow Tube)
Baker Full Opening Parallel Flow Tube Product No. 700
Anchor equivalent available
Baker Size 100 Series Model "D" Retainer Production Packer Product No. 415-D
(Installation shown for 7" Casing)
Baker Size 100 Model "E" Locator Tubing Seal Assembly Product No. 442-E2
Baker Model "DA" Retainer Production Packer Product No. 415-DA
Baker Production Tube
Baker Tubing Stop Product No. 704
Baker Model "D" Retainer Production Packer Product No. 415-D
Baker Model "E" Tubing Seal Nipples
Baker Production Tube

Fig. 4

Fig. 5

SINGLE-ZONE Fig. 1.—Illustrates Packer set in casing with Locator Tubing Seal Assembly and Production Tube installed for single-zone production.

PERMANENT-TYPE WELL COMPLETION Fig. 2—Illustrates typical Permanent-Type Well Completion Hook-Up showing perforating operation through and below the packer.

DUAL-ZONE, SINGLE PACKER Fig. 3—Illustrates Packer set in casing with anchored production string for dual-zone production. Tubing can be released from packer by rotating to right.

DUAL-ZONE, PARALLEL STRINGS, SINGLE PACKER Fig. 4—Illustrates the simplest form of parallel string installation. A variation permits anchoring short string to long string, if desired. Note full opening to lower zone for use of all permanent completion-type tools.

DUAL-ZONE, PARALLEL STRINGS, TWO PACKERS Fig. 5—Illustrates two-packer parallel string installation with each zone confined to its individual tubing string, with full opening to lower zone for use of all permanent completion-type tools.

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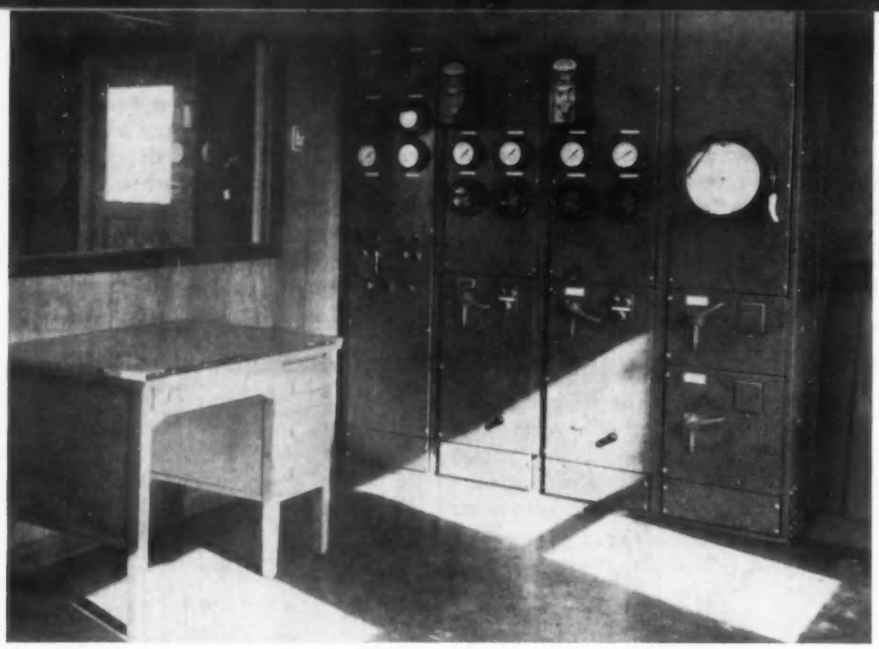


FIGURE 5—Interior view of control room. It includes ammeters indicating current in each electrical centrifugal pump and a four-pen recorder which graphs injection system pressure and water volume from the three supply wells.

pressure at an appreciable saving in installation cost. However, investigation showed that the inherently lower efficiency of the electrical centrifugal pump as compared to the triplex, would have wiped out these savings through increased power consumption long before it is anticipated the flood will be abandoned.

Power is supplied to the triplex pumps at 440 volts by a 112.5 KVA bank located adjacent to the plant. Each electrical centrifugal pump is supplied though a 45 KVA bank at 440 volts by extension of the 12,000 volt primary to the well site. The beam operated supply well takes power from the lease power distribution system which also powers the pumps at producing wells.

Instrumentation. Control of the supply wells and the triplex pumps is centered at the pump station in the control panel pictured in Figure 5. Control circuits at 110 volts are underbuilt on the power line poles to operate relays at each supply well. These in turn operate the contactors which close and open power circuits to the pumps. Ammeters for indicating current in each electrical centrifugal pump are located on the control panel. These indicate the operating condition of the pumps—whether shorted, stuck, or running normally. They are connected through control lines and current transformers to the power supply at the well.

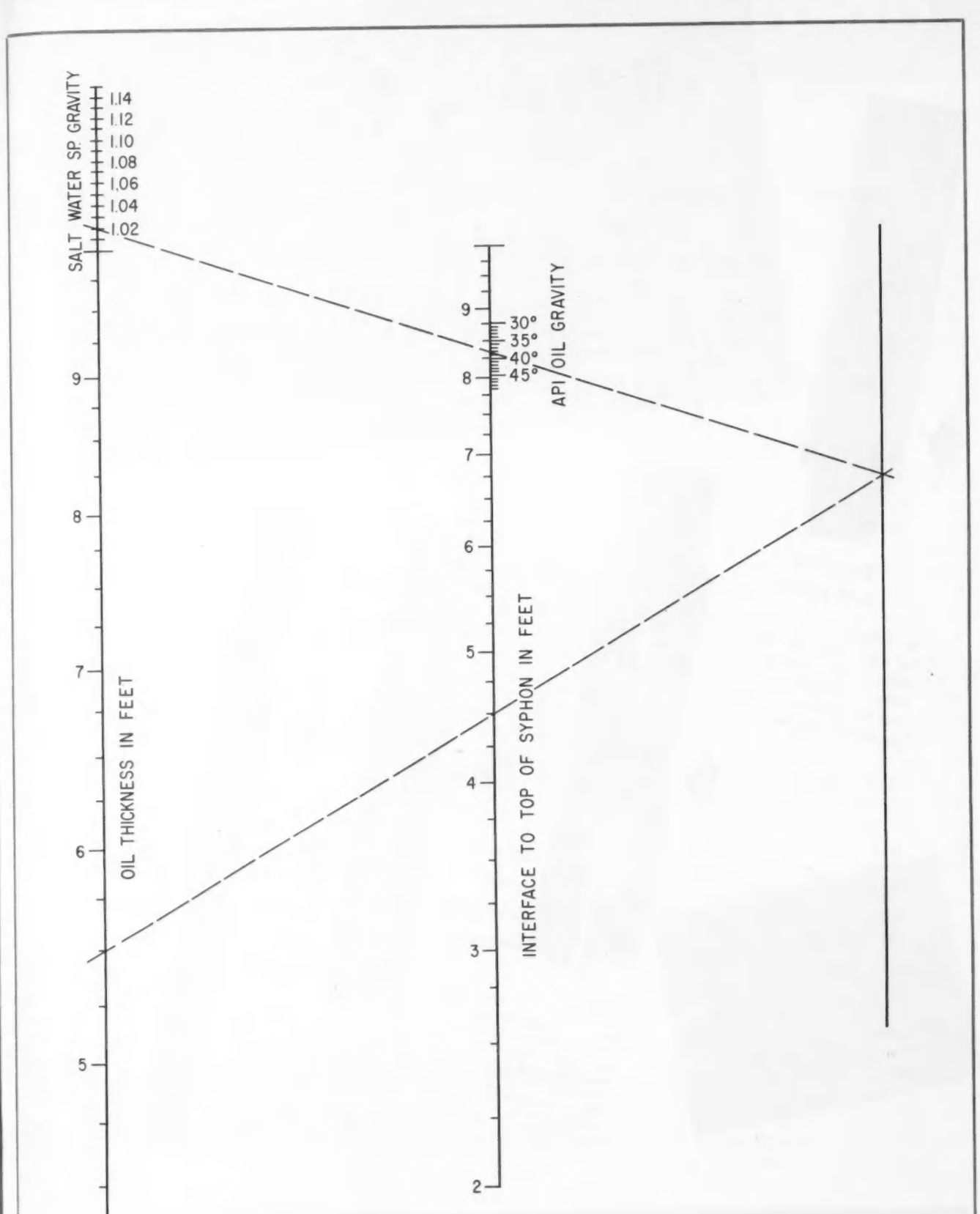
A four-pen recorder is located on the panel. One pen records discharge pressure on the injection system, while the other three record water volume produced from each of the three supply wells. These latter pens are the electrical impulse type and are actuated by switches built into the positive displacement master meters in each supply well line. Each meter is fitted with a special cam on the ten barrel position of the meter register that actuates the switch and thus causes a pip to register on the chart for each ten barrels produced by each supply well. Meters for the electrical centrifugal pumps are located on the suctions of the triplexes. Impulses from the beam supply well meter are transmitted approximately one-half mile to the recorder over control wires.

Each triplex pump is equipped with high discharge and low suction pressure shutdown devices. In addition, a ball float switch is provided on the vertical leg of the suction to each triplex to insure that the pump cannot operate without water in the suction line.

Injection Well Manifolds. A five-inch main line connects the plant to four injection well manifolds located adjacent to tank batteries serving the leases. Each manifold is supplied through a master meter and each injection well connection is equipped with plug valve, check valve, meter, adjustable choke valve, and pressure gage. In addition, a bull plugged tee is provided in each line to provide a connection for occasionally testing the meter against a standard. Figure 6 shows the arrangement of a typical manifold. Manifolds were located near tank batteries for the purpose of saving operator's time in the field. One stop at each of four locations allows him to gage and run tanks, read injection meters and adjust injection well input as required.

Initial start-up of the plant was early in 1956. Full capacity operation was maintained only for about 60 days to insure that the system would function as designed. After this time, the plant was shut down to await offset operators whose flooding facilities were not complete. Partial capacity has been supplied by the standby beam well and full capacity injection is expected to be underway early in 1957. Performance of the system was excellent during the short test period. —**The End**

FIGURE 6—Typical injection well manifold showing proximity to tank battery. Master meter at extreme right measures incoming water to manifold.



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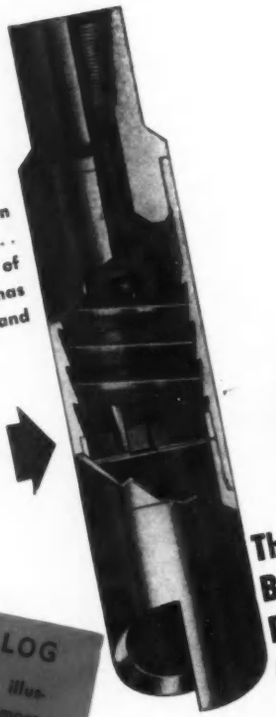

The Bowen Releasing Overshot

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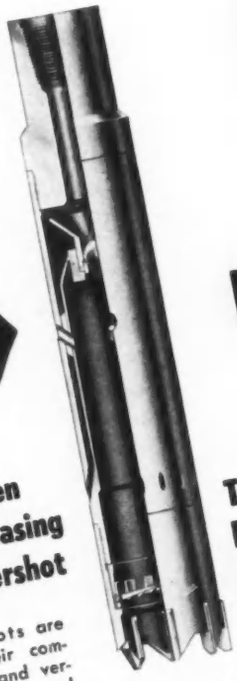

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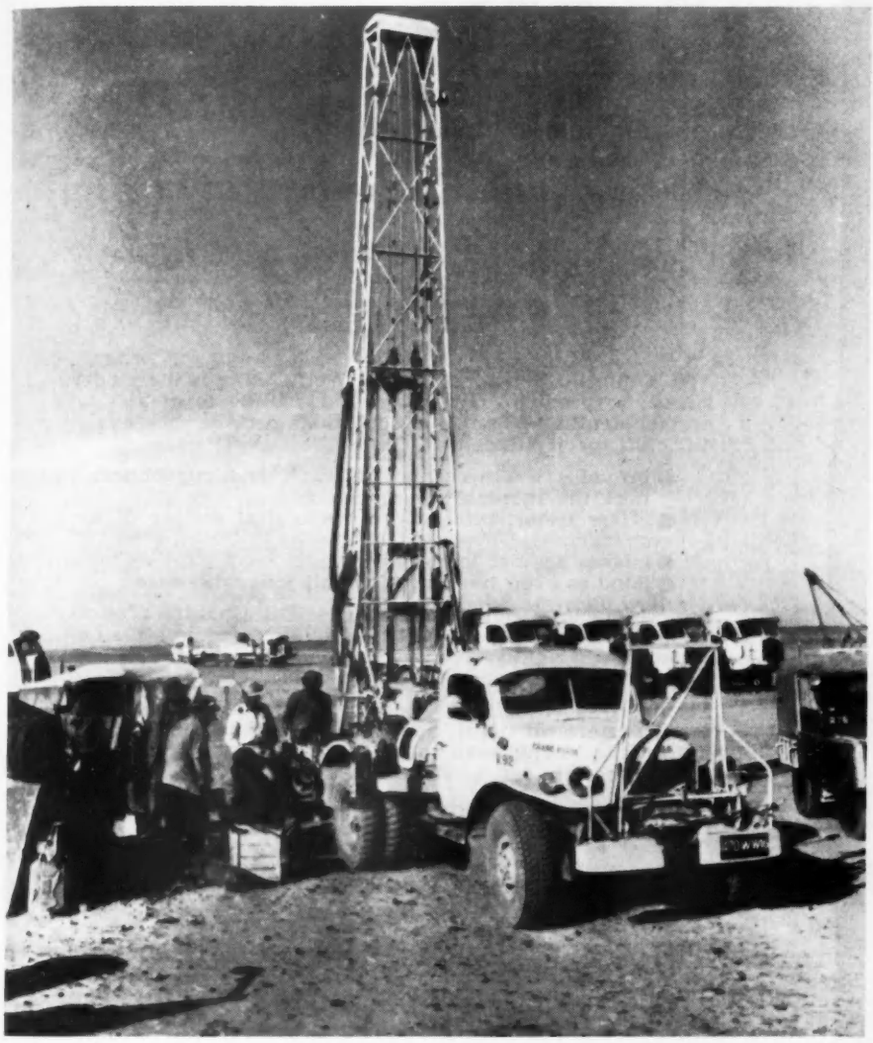


This seismic party is preparing to leave its Algerian Sahara Desert camp on a survey operation. In the immediate foreground is a portable drilling rig. The Compagnie des Petroles d'Algerie, in which the Royal Dutch Shell Group has a 65 percent interest, is actively engaged in the exploration of more than 60,000 square miles of Algerian Sahara. Considerable reconnaissance work has been carried out in the neighborhood of El Golea, about 435 miles south of Algiers. Geophysical and gravimetric survey groups have been in operation since the beginning of 1954.

Africa Success Highlighted By Blocking of Suez Canal

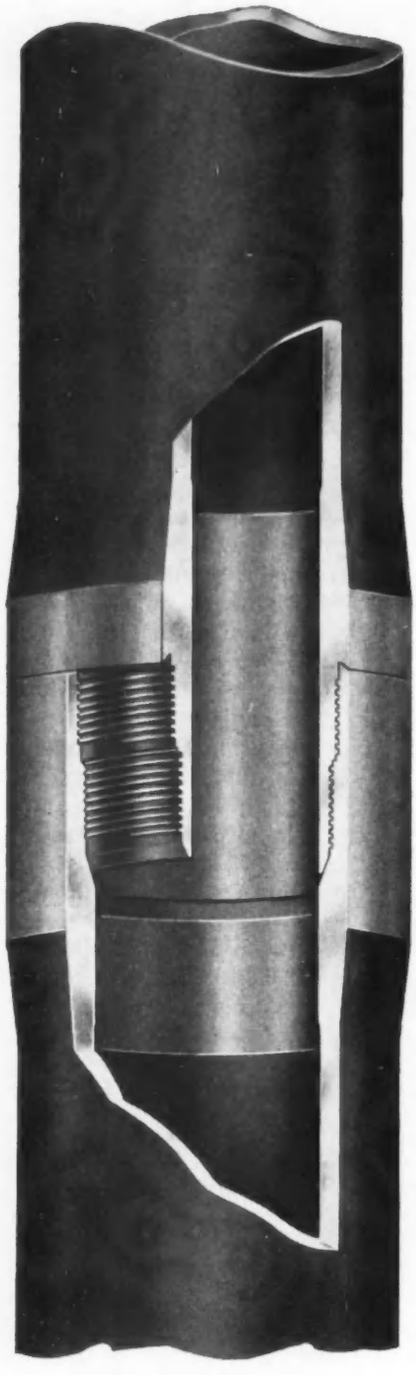
Promising new oil discoveries in the continent's northern and western regions are undergoing rapid development. Recent Algerian find may prove to be a major crude reserve.

COMMERCIAL PRODUCTION OF crude oil has been discovered in North and West Africa during the past two years, far distant from previously-known deposits in the Suez graben area of Egypt and several small fields in French Morocco and northern Algeria. Sizable oil fields have been found in widely separated coastal points in West and Southwest Africa, in French Equatorial Africa and Angola. Recent oil discoveries in Nigeria await further evaluation before their economic worth is known. Promising indications of oil have been encountered in the Cameroons and in Senegal. Four oil discoveries and several natural gas finds have occurred in remote inland Algeria. Further evaluation drilling must be done before major pipe line projects essential to moving the newly-found Algerian crude to European markets can be justified.

However, one of the Algerian oil discoveries may be a major reserve. In any event, the importance of these new fields has been compounded by the blocking of the Suez Canal. The canal would not be a factor in the export of crude from North and West Africa to Europe. Hence, European nations without adequate domestic crude supplies are watching African oil exploration results closely.

Algeria. The most promising discovery to date in Algeria is the new field found by Societe Nationale de Recherches et D'Exploitation des Petroles en Algerie (SN REPAL) at Hassi-Messaoud 1. Capital of the company is 50 percent in the hands of the Algerian government and 48.45 percent owned by the French Bureau de Recherches de Petrole. The location is in the remote eastern Sahara desert, 63 miles southeast of Ouargla in a vast open area called the Grand Erg Oriental.

Location of the test well reportedly was made on the basis of refraction seismic data, with the lower Triassic beds in which shows had been found in other remote Algerian wildcats being the target. The Hassi-Messaoud test was one of the rankest wildcats ever drilled, being about 60 miles



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A smaller outside diameter provides additional assurance casing will go to bottom. In some fields its smaller OD permits a reduction in hole size—thereby lowering drilling costs.

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from the nearest deep test and 200 miles from the nearest production. The well was spudded in in 1956 and was completed in January, 1957, at a total depth of 14,508 feet.

At 5100 feet, the well was reported in Cenomanian strata. At 7635 feet, it had drilled into Triassic beds, and flowed nine barrels of salt water on a two-hour drillstem test at that depth. In lower Triassic, good oil shows began to be found. At 10,925 feet, quartzitic sandstone was cored, saturated with oil. On a drillstem test from 10,922 feet to 11,040 feet, the well flowed at the rate of about 15 barrels per hour. Considerable coring and testing followed. By November, 1956, the test had penetrated 459 feet of saturated lower Triassic oil sand, having reached a depth of 11,381 feet. The crude is reported to be about 35 gravity and of good quality. Many estimates of the potential of the Hassi-Messaoud well have been reported, varying widely up to 6280 barrels per day.

Only further development drilling can determine the outcome of this interesting discovery. The pay zone, being non-marine lower Triassic, either of lacustrine or aolian origin, is suspect, since Triassic rocks have produced oil in very few places in the world, such as the Peace River area of Western Canada and in some Argentine localities.

The Triassic has also been found productive at Talemzane in Algeria recently, 175 miles northwest of Hassi-Messaoud 1. The lower Triassic in eastern Algeria and in Tunisia has been found to be very erratic—fairly thick in some places and totally absent in others, as may be expected of a sand of aolian or lacustrine deposition. However, it may be found that an unconformity governs such Algerian Triassic oil deposits—and to sell short unconformities as oil traps would be tantamount to minimizing the importance of such fields as East Texas and Oklahoma City.

SN REPAL is drilling a long step-out well, Hassi-Messaoud 2, located seven miles south-southeast of No. 1, reported drilling in the Tertiary at 509 feet in late February, 1957. This well should cast much light as to whether this remote find is to have a pipe line outlet under way at any near future time.

The other recent Triassic find in Algeria was made at Talemzane by Compagnie Francaise des Petroles (Algeria) (CFP-A). The rank wildcat was spudded May 29, 1956, on the east edge of the Laghouat permit 220 miles south of Algiers. A 30-foot thick lower Triassic oil sand cored in the interval 8921-53 feet tested 100 barrels of crude oil with gas in six hours and fifteen minutes. A second well, located 1.2 miles north-northwest, was drilling at the end of 1956.

Far Eastern Sahara discoveries by CREPS. Two oil fields were found in the far southeastern Sahara desert area in 1956 in the Fort Flatters area by Compagnie de Recherches et Exploitation de Petrole au Sahara (CREPS).

The initial discovery, at Edjele 101, was two miles west of the Libyan border (see WORLD OIL, August 15, 1956, pp. 284-285). This core test was drilled to 2890 feet and was completed as an oil well, testing 19 barrels per hour of 35 gravity sweet crude from 1475 feet in Mississippian. Subsequent drilling indicates that this field may have considerable areal extent from north to south, but may be a narrow structure in the east-west direction.

Edjele 102, located 1148 feet west of the discovery, was drilled to 2904 feet and tested salt water. However, Edjele 103, slightly less than two miles south of 101, tested 19 barrels of oil per hour from the field pay and appears to have extended the field. A long five-mile stepout to the south, Edjele 1 (not a core drill operation) drilled to 3839 feet and found basement rocks. This well tested gas at the rate of 2 Mmcf daily from 1342 to 1414 feet and was shut in. The well also was reported to be oil productive.

Tiguentourine. A second shallow CREPS discovery during 1956 was made 40 miles west of Edjele in another core hole, Tiguentourine 101. This test was spudded May 6, 1956, and found oil at two intervals, flowing 25 barrels per hour at 1640 feet and 38 barrels per hour at 2625 feet.

All crude found in the area has been described as light and of high quality. On Sept. 25, 1956, Tiguentourine 1, located 2625 feet northeast of the discovery well, was spudded. At about 1300 feet it tested about three barrels of oil in two hours.

CREPS also has made some promising gas discoveries on Paleozoic structures centered about 300 miles southwest of Port Flatters. A pipe line of at least 800 miles would be necessary to transmit southern Algerian natural gas to Algiers, the nearest potential immediate market.

All the recent Algerian discoveries, the two Triassic finds excepted, appear to be structurally controlled.

Large scale pipe line projects will be necessary to transport the newly-found Algerian crude to the Mediterranean Sea. A crude line from Edjele field to the port of Gabes in Tunisia would be about 500 miles long. A line from Hassi-Messaoud to Gabes would span about 300 miles; one from Talemzane to Gabes, about 375 miles. Or a common crude transmission system linking Edjele, Tiguentourine, Hassi-Messaoud and Talemzane across the Atlas Mountains with Algiers would cover about 900 miles.

Strenuous efforts to define the extent of the new fields quickly are being made to determine if these fields, individually or collectively, can justify such projects. The French companies are talking in terms of at least $25 million to be spent for pipe lines if the new fields meet expectations. M. Lemaire, French Secretary for Industry and Commerce, was quoted in Paris February 19 as saying that oil from the Sahara desert should reach the Mediterranean coast by pipe line by January, 1960.

Coastal West Africa. A much clearer picture of commercial crude oil production, close to deep water and already being exported, is presented by French Equatorial Africa and Angola. Three promising areas, Senegal, the Cameroons and Nigeria, were still in doubt by February, 1957. In the Cameroons, Societe de Recherches et D'Exploitation des Petroles du Cameroun (SEREP—CA) had found a large flow of gas distillate at Logbaba, a short distance inland from Douala, but oil shows at about the same depth range (5200 feet-5800 feet) had not yet led to commercial oil production. A second gas distillate discovery at Souellaba on the (Atlantic) coast, at a depth of 8812 feet to 8845 feet was completed during 1956, following the Logbaba discovery in 1955.

In Senegal, Societe Africaine des Petroles (SAP) drilled 12 wells during 1956 and was drilling a thirteenth

Continued on Page 254

1 The Arabian American Oil Company's pipe-laying barge (center foreground) is laying a trunk pipe line in the Persian Gulf waters off the eastern coast of Saudi Arabia which, when it it completed this spring will connect . . .

2 . . . Aramco's Safaniya oil field, the first offshore desposit discovered in the Persian Gulf and the world's largest marine offshore field, which is being developed with the aid of the company's drilling barge nicknamed . . .

Saudi Arab Offshore Field

Twenty-two inch, 142-mile crude oil pipe line scheduled for completion this spring to link world's largest marine offshore producing area with Aramco's Ras Tanura refinery and terminal.

By H. T. BRUNDAGE
World Oil Staff

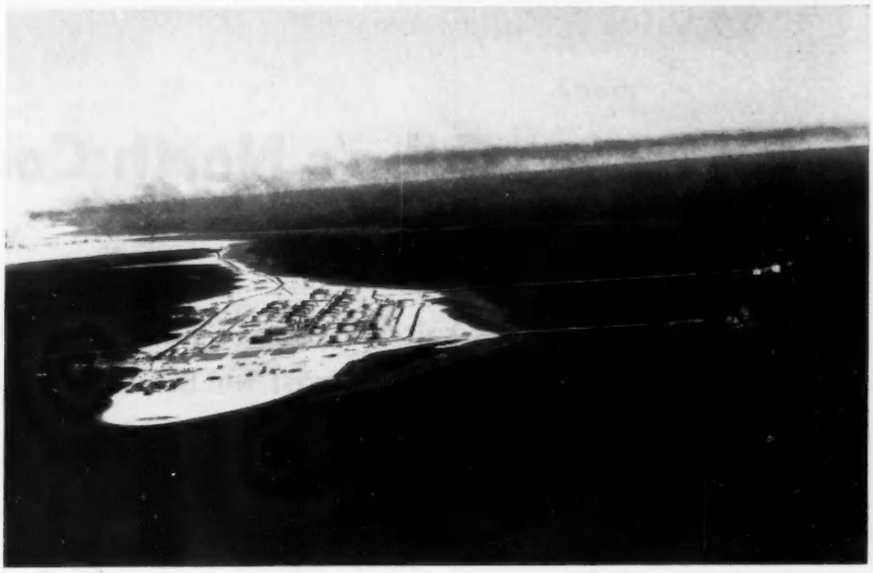
Arabian American Oil Company is in the process of completing its new 142-mile coastal 22-inch crude oil pipe line that will link the huge Safaniya oil field with the Ras Tanura refinery and terminal. Construction began in January, 1956. International Bechtel Brothers, Inc., of San Francisco is the contractor for the project which will cost about $21 million, including $11 million for the line itself and $10 million for attendant facilities, expansion of existing installations and other miscellaneous items.

Initially, the pipe line will be capable of handling 50,000 barrels of crude daily from wells now shut in, but it and the gas-oil separator plant at Safaniya are being constructed so as to allow production of up to 125,000 barrels daily by mid-summer 1957. Plans call for later installation of additional gas turbine pumping facilities to permit a maximum rate of flow of 190,000 barrels per day by mid-1958.

Safaniya, the biggest marine offshore oil field yet proven anywhere in the world, was discovered in 1951 and is the first offshore production found in the Persian Gulf. To date, 2 wells have been completed onshore and 20 offshore in waters up to 45 feet deep. There is one observation well.

Production is from about 5000-5600 feet in two Cretaceous horizons, called the Zubair and Bahrain zones. Production found here is the only commercial Cretaceous pay found so far in Saudi Arabia, though one of the pays is correlative with the pro-

the Queen Mary, left background (a test barge containing a gas-oil separator trap and other testing facilities is shown at right) with . . .



3 . . . The Ras Tanura terminal which, with the Ras Tanura refinery, shown above at the upper left, will be the terminus of the new pipe line. The expanded terminal facilities, with their two T-shaped loading piers and 40 storage tanks, are capable of handling the largest tankers afloat.

to Go on Production Soon

ducing zone on Bahrain Island, 175 miles to the southeast. The current market situation causes the crude from the Bahrain zone to be more in demand. Only two producing wells are completed in the Zubair zone at Safaniya, and these are both dually completed to produce the Bahrain zone also. Development wells at Safaniya have been widely spaced to determine the extent of the reserve. The field has thus far been proven to extend more than ten miles offshore, and 70,000 surface acres appear to be productive.

This crude as produced contains no H_2S. It is paraffinic, has a gravity of 27, a high fuel oil yield and a considerably lower gasoline, kerosine and diesel oil yield than other Arabian crudes. Previously, there had been no special market for Safaniya crude, but the recently increased worldwide demand for fuel oil and lower proportionate demand for gasoline have made it desirable to put the Bahrain zone of Safaniya Field on production. This crude produces gasoline with excellent response to tetraethyl lead, being superior to that from other Arabian crudes. Other significant attributes of stocks from this crude include a kerosine distillate of excellent burning quality, high cetane number gas oil and high quality lube oil. The residuum is heavier and of higher sulfur content than other Arabian crudes and the yield of asphalt is higher. This crude contains appreciable vanadium and has a low salt content.

How to move Safaniya production was open to three alternatives—by tanker, by the Trans-Arabian pipe line, or by a new pipe line to refining and/or tanker loading facilities at Ras Tanura:

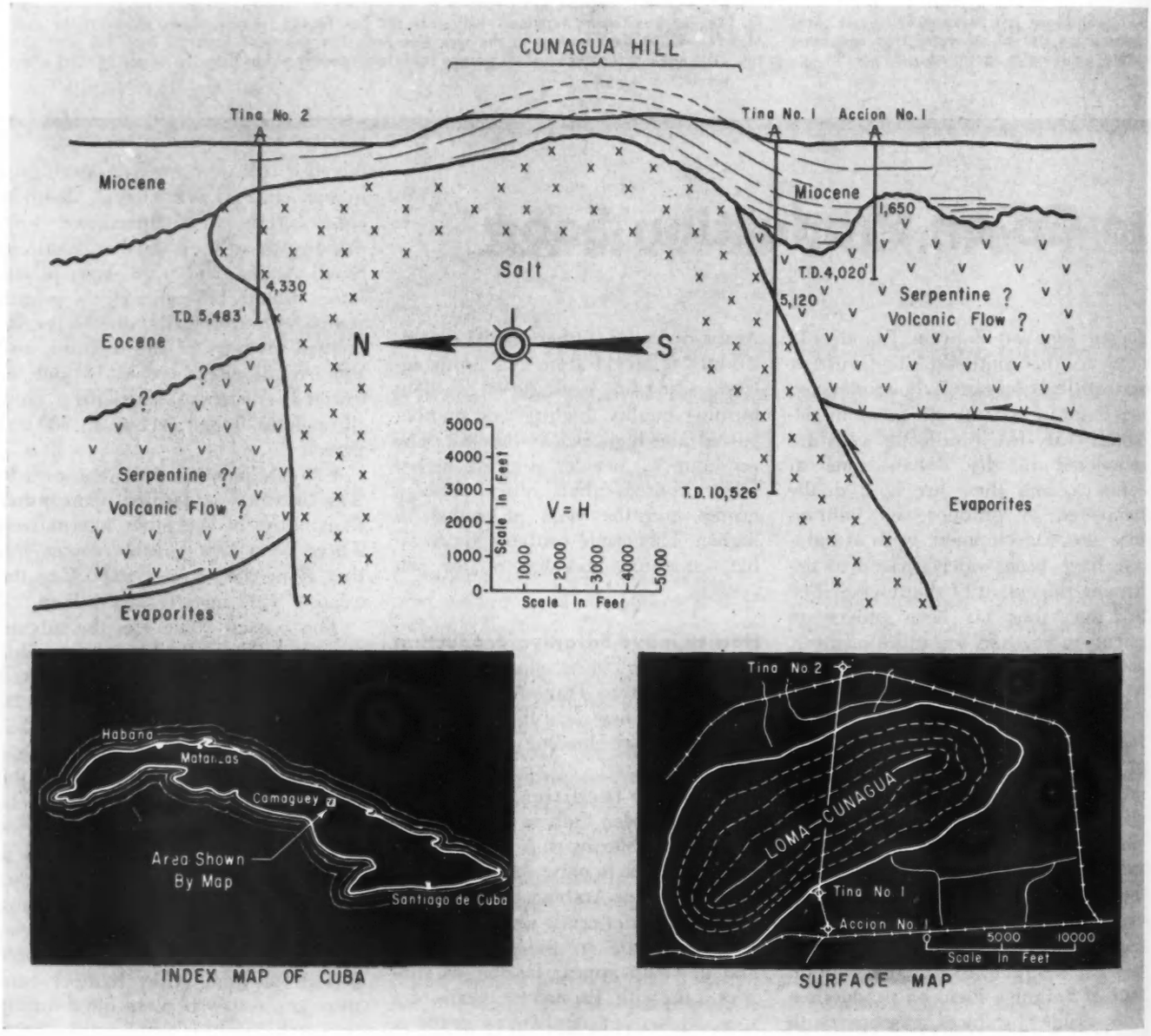
- Loading facilities for tankers could have been built in the Safaniya area for transfer by ship to a refinery.
- The field is only about 40 miles from the trans-Arabian pipe line system that carries crude across the Arabian peninsula to Sidon, Lebanon, and it would appear feasible to connect it up with Tapline by means of a spur. However, Safaniya crude is more viscous than other Saudi Arabian crudes with which it would be mixed if this were done. Aramco estimated that if Safaniya (Bahrain zone) crude were intermixed with crudes produced farther south in Saudi Arabia, the throughput of the latter would be reduced by several thousand barrels daily, due to the increased viscosity of the mixture, and the overall effect would be one of lowered efficiency. Tapline's daily throughput is in excess of 300,000 barrels.
- A new pipe line from Safaniya to Ras Tanura was decided upon rather than either of the other alternatives. There were two possible routes—either along the coast or parallel to the existing pipe lines farther inland.

The coastal route has the advantage that there is less topographic relief and less rock to be blasted, and the line is less apt to be buried in 30 to 50 feet of wind-blown sand that would hamper maintenance and repairs than is the case farther in the interior of Arabia. There is one problem peculiar to the terrain, that of the *sabkhah* or salt flat, which is worse along the coastal route. Following very high tides or rare rainstorms, these inland topographic troughs can stay filled with water for considerable periods of time. They hamper construction if they become filled during or just before the building of a pipe line.

Continued on Page 256

Cuba's North Coast Offers Good

While island's salt domes may not be as favorable as those on the Gulf Coast, possibilities are believed to exist for the discovery of a major oil field structure-reservoir combination.



Loma Cunagua Salt Dome. This cross-section map showing a salt dome is one possible solution to the structural question of the Cuban discovery made in 1956.

Exploration Prospects

By **HARRY WASSALL**
Havana

ONE OF THE MOST important developments in Cuban oil exploration in 1956 was the discovery of what appears to be Cuba's first salt dome. This feature was determined from subsurface information in three tests drilled by the Cuban Kewanee Oil Company on a farm-out from Atlantic Refining Company. The first two were drilled with rigs rented from the Cuban Government.

A pre-Tertiary evaporite section has long been known to exist on the north-central coast, consisting of Cretaceous and Upper Jurassic primary dolomites and anhydrites with a few interbedded dense limestones. It is approximately correlative to the dolomite-anhydrite section of southern Florida. The known surface occurrences in Cuba are relatively few—consisting of outcrops of gypsum (derived from anhydrite) and dolomite in the Punta Alegre and Turiguano areas of northern Camagüey Province. In the subsurface, dolomite and anhydrite are known in Shell, Cayo Coco 2; Shell, Punta Alegre 1-A and Shell, Punta Alegre 2.

All of the Cuban Kewanee tests were located on the north coast of Camagüey Province around Loma Cunagua, a sharp, wooded, topographic high which rises abruptly from the flat, cultivated, coastal plain. Surface elevations in all of the tests are only a few feet above sea level.

Geophysical work by Atlantic and other major companies has indicated that a gravity minimum coincides with this hill. Surface mapping indicates that it is a strongly folded anticline in Miocene limestone, dolomite and anhydrite, with dips on the flanks in the order of 30 degrees. The anticlinal axis trends in a north-east direction, in contrast to the north-west regional strike of the formations on the north coast of Cuba. However the axis of the gravity minimum trends parallel to the regional strike.

Tina 1. The first test, Tina 1, was drilled as close as possible to the southern side of the hill. According to fairly reliable scout reports, the section is as follows:

0 feet-2,970 feet—*Miocene*—limestone, anhydrite, dolomite (the lower 1,500 feet may be Eocene).
2,970 feet-5,120 feet—*Cretaceous (?)*—volcanics or serpentine.
5,120 feet-10,526 feet—*Upper Jurassic or older*—impure salt.

The salt only constitutes about 80 percent of the section since it has a uniform dissemination of red clay, as well as scattered fragments of anhydrite, red shale and green shale. Although entered at about 5120 feet, only the impurities were recovered in ditch samples. First indications of the true lithology being drilled came from a core at 5989 feet-6005 feet.

Some of the cores have a definite horizontal banding, formed not by bedding but mainly by alignment of salt crystals in horizontal planes, with elongation of all the crystals in the same direction. To a lesser degree, there also is horizontal alignment of tabular fragments of impurities, such as anhydrite and shale.

The section found from 2970 feet-5120 feet is, in part, a dark green, dense rock which appears to be very finely brecciated. It may be serpentine or volcanic flow rock with the original textures destroyed by brecciation. It is possible that some anhydrite which has been reported in this section represents vein filling, which occurred because of proximity to the side of the salt dome.

About the Author

HARRY WASSALL, a consulting geologist in Havana, was graduated from Tulsa University in 1942, and served as an engineer officer with the U. S. Navy in the Pacific. He spent three years with Shell Oil Company in north-central Texas and four years with Gulf Oil Corporation in Cuba.

During the last two years, he has formed a consulting organization that offers complete geological services for the Caribbean area and Latin America.

Electric log, micro log, gamma ray log, dipmeter survey, and velocity survey were run on Tina 1, and, since no oil shows or promising zones were found, the hole was plugged and abandoned.

Tina 2. A second test, Tina 2, was drilled about 4000 feet north of the northern edge of the hill, and according to fairly reliable scout reports, found the following section:

0 feet-850 feet—*Miocene*—limestone.
850 feet-1,340 feet—*?*—red and green shale with sandstone stringers and anhydrite.
1,340 feet-4,330 feet—*Upper Jurassic*—impure salt.
4,330 feet-5,483 feet—*Eocene*—limestone, coarsely fragmental and detrital and gray shale.

The salt in this well is similar in lithology to that found in Tina 1, but was entered at 1340 feet (3780 feet higher than in Tina 1) and then went out of it at 4330 feet. This suggests that an overhang of a true dome may have been found. Tina 2 was projected to 10,000 feet, but was abandoned at 5483 feet where a four-foot cavern caused two difficult fishing jobs and deterioration of the hole.

Accion 1. The last test drilled in this

Continued on Page 261

This electric coring traveling laboratory is operating at a well in the Parentis region of France.

New Test to Determine Deep Prospects at Parentis Field

Proposed well will be drilled to 15,000 feet to study Jurassic and Triassic formations beneath established reservoir of an estimated 175 million barrels.

DOES DEEPER oil lie beneath France's Parentis field?

Belief that it might has led to preparations for a test to be drilled by Societe Esso de Recherches et d'Exploitation Petrolieres (Esso REP) through the 7500-foot level from which Parentis wells now are producing. Reserves at Parentis currently are estimated at approximately 175 million barrels.

It is believed that other oil-producing formations may exist in the Jurassic or Triassic or even lower, and the proposed test is scheduled to reach 15,000 feet.

Parentis field, which is in the Aquitaine basin in southwestern France, was discovered in 1954. Out of 20 wells in the area, 18 are producing and the two on the edge of the formation are drying up. Total production for 1956 was expected to reach about 7 million barrels, or an average of slightly more than 19,000 barrels daily. As a conservation measure, production has been pegged at a rate expected to continue for 20 years.

However, other producing wells are scheduled to be drilled at Lugos, 20 miles northeast of Parentis, in the near future.

Esso REP, formed in May, 1954, to develop Esso Standard SAF's Parentis field, is owned 89 percent by Esso Standard SAF (63.2 percent Jersey Standard, 18.349 percent Gulf Oil Corporation, and 18.451 percent French investors), 10 percent by the French government through its Bureau de Recherches du Petrole (BRP) and 1 percent by FINAREP, a French company holding minority interests in 13 other French oil companies.

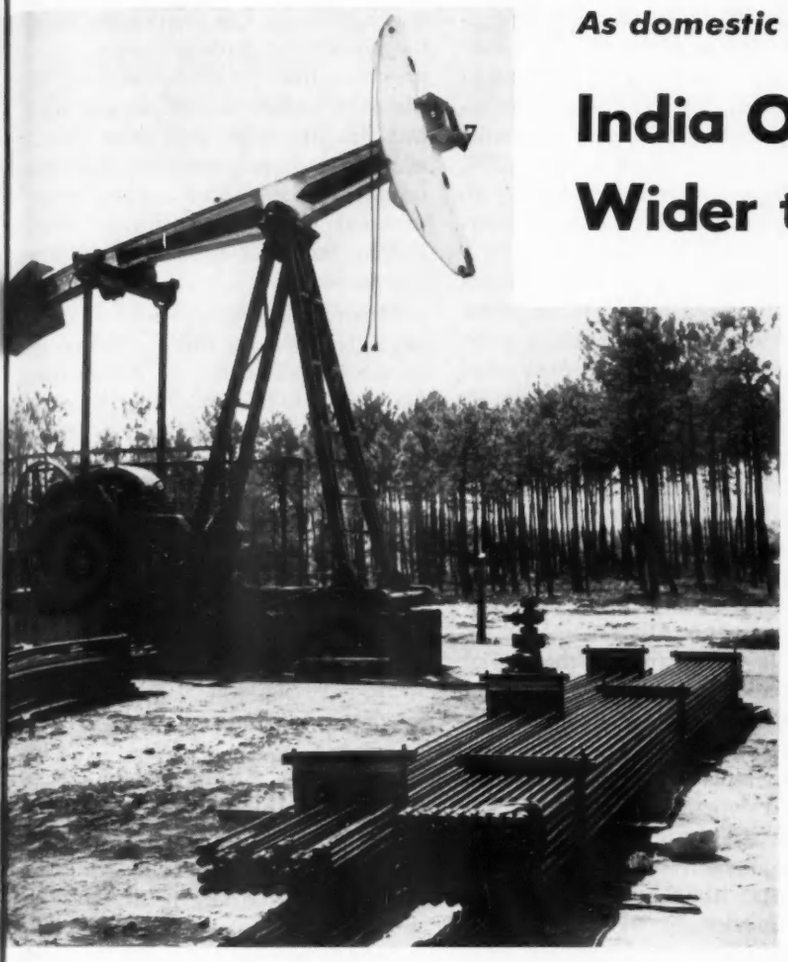
Among the 18 producing wells at Parentis is P 11, which is yielding almost 3800 barrels of oil per day—credited with being the largest producer in Europe. P 11 is one of the five offshore wells located in the Lake of Biscarosse.

Parentis production, after degassing, is moved by pipe line 2 miles to the railhead at Parentis, where it is pumped from 18 loading stations into 108 tank cars daily. The crude is moved by rail to the port of Ambes, thence by tankers around the Atlantic coast and up the Seine river to the Port-Jerome refinery, near Rouen.

This circuitous route will be eliminated through the construction of a 10-million-barrel refinery at Ambes which will refine Landes region crude

As domestic demand for new oil grows . . .

India Opens the Door Wider to Private Capital



Wells on the border of the east-west anticline at Parentis have dried up. However, a newer formation has been found at Mothes, eight miles northeast of the principal field, where this photograph was taken.

and, eventually, that of all southwest France.

Factors in the belief that a sizable reservoir of undiscovered oil exists in the region in addition to Parentis field, which now supplies 6 percent of France's domestic requirements, are Mothes and Carcans.

At Mothes field, eight miles southeast of Parentis producing area, one well produced more than 83,000 barrels in 1955 and currently is producing about 350 barrels daily. And in the neighborhood of Carcans, northwest of Bordeaux, oil indications reportedly have been discovered.

The cost of bringing a well into production in this region ranges from $325,000 to $425,000. Hard limestone formations require the use of a sizable number of bits in each hole. Electrical coring is handled by a French firm, and a French turbodrill, developed by a Grenoble company, has proved moderately economical despite the high initial cost.

Meanwhile, plans for the construction of a pipe line to transport oil arriving at Marseilles to the Rhine area reportedly have taken shape, and have developed into plans for a trans-West European artery. This pipe line would begin at the Mediterranean port, crossing East France, Switzerland, Luxemburg, West Germany, and Belgium.

A company has been formed—the SAPEUR, with headquarters at The Hague, Holland, which is studying the route and requirements of a pipe line to transport Middle East crude from Marseilles to Rotterdam and Antwerp.

Associated in this new company are The British Petroleum Company, California Texas Co., Compagnie Financiere Belge des Petroles S. A., Compagnie Francaise des Petroles, Deutsche Erdoel A.G., Gelsenberg A.G., Royal Dutch/Shell Group, Society Pechelbronn, Ruhr Chemie A.G., Solvent Chemie A.G., Socony Mobil Oil Co.; Standard Oil Company (New Jersey), and Union Rheinische Braunkohlen Krafstoff A.G.

—**The End**

By DON KLIEWER, World Oil Staff

With demand for oil spiraling in India, as it is throughout the Far East, the Indian government is actively behind efforts aimed at alleviating its continuing shortage of domestic production. Importance of this move is underscored by the fact that domestic output furnishes only about 5 percent of India's total requirements of approximately 135,000 barrels a day (World Oil, July, 1956, Page 174, and August 15, 1956, Page 364).

For these imports, India turns to the Middle East and Indonesia. Indonesia currently is the No. 1 crude producer in the Far East; however, exploration activities are being accelerated in Japan, Pakistan, Papua, Netherlands, New Guinea, New Zealand, British Borneo, the Philippine Islands, Formosa and Australia, in addition to India.

This intensified exploration is not limited to the Free World. Harry W. McCobb, vice president and director of Standard-Vacuum Oil Company, recently reported that new drilling in Northwest China and the Central Asian provinces of Russia had been indicated.

Thus, the movement by official India toward intensified exploration for new oil indicates a significant policy change in this nation, which is so strategically located between the Middle East and Far East.

Recently, when asked for the highlights of India's oil industry during 1956, the official governmental answer listed first the discovery of commercially workable oil reserves in the Brahmaputra valley at Nahorkatiya and Moran (World Oil, March, 1957, Page 185).

While recognizing this acute need for additional domestic oil, the Indian government has recognized a paralleling need: the institution of more favorable concession terms with which to attract private capital inter-

est from abroad. In contrast to Italy, where Gulf Oil Corporation recently brought to a halt its operations on the mainland because of the adoption of more stringent regulations governing private capital operations, India's government has formulated oil exploration concession terms which are designed to attract firms from abroad—especially from the U. S. and West Germany—to undertake oil exploration programs. It is generally conceded that these proposals already would have been adopted but for the fact that general elections were scheduled to be held at the end of March.

The Ministry of Natural Resources and Scientific Research, which adopted resolutions governing monetary and technical participation of oil firms from abroad after studying concessions in less advanced oil producing countries, now is understood to have the view that India's current oil regulations are too stringent and that there is a need for the revision of both the leasing period and the area covered by licenses.

Now, a lessee can obtain rights for exploration and development of oil within a limited area. Such a lease is renewable at the option of the Indian government.

Current proposals would limit the initial lease period to 21 years, but would allow the lessee to renew his lease for a period of ten years at a time—so long as the area continues to produce oil. Also, they would permit the area which could be developed under terms of a given license to be extended to cover 300 square miles.

Private capital from abroad has been slow to participate in India's oil development. Standard-Vacuum and Assam Oil Company currently are the only companies from abroad conducting oil exploration programs to any extent in India. All of the nation's current oil is produced by Assam Oil from the old Digboi field, discovered in 1889 but recently extended, and the Nahorkatiya field, discovered in 1954.

The first systematic survey was conducted with the assistance of Russian experts, but informed sources say the survey yielded no new results. A team of Rumanian experts and technicians was scheduled to begin exploration activities in the Jwalamukhi area of the Punjab at the end of February or the beginning of March, when the first government rig, bought from Rumania, was to have gone into operation.

The complete drilling rig was bought from Rumania by the Indian government in March, 1956, and originally was to have been set up in July, 1956, and to have commenced drilling in August. However, the project reportedly was delayed by rains.

Russian experts who toured India last year reported considerable promise of oil in the Jwalamukhi region. Wildcat drilling will determine whether it exists in commercial quantities. If initial tests prove successful, two other drilling rigs purchased from Russia and expected to arrive in India "shortly," will be set up in the same region.

Another team of Russian geophysicists has arrived in India on a six-month contract to survey the Hoshiarpur and Jaisalmer areas of the Punjab (India) and Rajasthan. A proposal has been made to send with this Russian team a number of Indian government trainees so they may obtain some field experience.

During the process of selecting trainees, about 150 candidates were examined by the Union Public Service Commission of the Government. Presumably because of an overload of work, the commission has not announced results of these examinations. Consequently, an interim proposal was made that all 150 candidates be attached to the Russian team with a provision that those who did not fulfill expectations would be dropped. But this proposal hit a snag because of an irregularity: the candidates cannot be treated and recognized as government employes until the Union Public Service Commission approves the project.

Meanwhile, Standard-Vacuum reportedly hopes to drill its initial test in the Ganges valley by May. Assam Oil, which discovered oil in the Nahorkatiya-Hugrijan area and at Moran, is continuing its exploration program. These operations will be taken over, however, by the Assam Oil-Government rupee company when it is formed as proposals for this development have been approved by both parties.

Following an official study claimed to be a "searching examination of possible profits and remittances of foreign oil companies operating in India," formation of a new Ministry of Oil and Fuel has been recommended. It is estimated that a major savings can be achieved by bringing the oil price policy in India in line with the prevailing practice in Europe. The proposed ministry likely will not be set up until after the general elections although it is known that Prime Minister Nehru favors the proposal.

Among the steps recommended are "a review of the refineries' profitability and reduction of their retail price structure to the level in the United Kingdom . . ."

It is expected these changes could be effected without infringing terms of the government's current agreements with refining companies in India—Burmah-Shell and Standard-Vacuum.

With a view toward conserving foreign exchange, stricter control over remittances by refineries and production of a wider range and volume of petroleum products are envisaged. Another recommendation is to ask foreign refineries to plough back a portion of their profits for investment in India.

Oil companies are estimated to have remitted more than $108 million during the 18-month period ending June, 1956. During the same period, a foreign exchange allocation of almost $223 million was made for importing crude oil and petroleum products. —**The End**

Rising Demand Soaking Up Soviet Production Increase

Steadily expanding Soviet oil production is being rapidly taken up by expanding domestic demand, owing largely to the availability of supply. Rapid dieselization of the railways, conversion of ships from coal to oil fueling and industrialization are also contributing to a heightening demand picture for oil.

In addition, severe cutbacks of imports of Polish coal and Hungarian oil have put pressure on the Russian fuel supply. Exports of oil from Austria required by the peace treaty of 1955 will be fulfilled in ten years, and there is some likelihood that Austria will step up shipments to fulfill treaty terms in seven and a half years instead of ten.

These considerations have caused Russia to go slow on exports to Western Europe, though heightened efforts to claim a bigger part of this market made available to Russia by the Suez crisis may be expected.

Brahmaputra Wells Prove Successful Producers

Of 26 wells completed at Nahorkatiya and nearby Hugrijan, both oil fields discovered during the past two years in India's upper Brahmaputra Valley, 23 have been successful producers. Burmah Oil Company reports an additional oil discovery at Moran, 25 miles west of Nahorkatiya, where the deepest test in Southeast Asia, 13,379 feet, has been completed. Production of 60,000 barrels daily from this region is considered possible by 1959.

Burmah Oil has said 50,000 barrels and 45 million cubic feet of natural gas could be produced daily for many years on the basis of reserves found so far. It will be difficult to satisfy transmission and refining needs if this oil is to serve uses outside the region where it is produced.

a WORLD of OIL

By **DON KLIEWER,** World Oil Staff

AUSTRIA: Of Rohoelgewinnungs A. G.'s three wells being drilled in the Mattighofen area, Puchkirchen 1 has been put on the pump with a daily yield of 88 barrels; Puchkirchen 2 had reached 8598 feet; and Geretsberg 1 was drilled to 7101 feet . . . Seismic activities in the Neukirchen-Aspach are continuing, where RAG will put into operation this year a recently-purchased U. S. portable drilling rig capable of drilling to 10,500 feet.

CHINA: Karamai oil field in Sinkiang and Chiuchuan Basin in Kansu reportedly are producing more than twice the undisclosed quota established for the First Five-Year Plan . . . In the past two years, it is claimed, oil has been discovered in almost a "hundred sites" in the Tsaidam Basin in Chinghai, with the largest deposit covering almost 390 square miles . . . Claims that further additional oil discoveries are being made currently stem from Szechuan, Kweichow and Kansu.

CZECHOSLOVAKIA: Annual domestic requirements now are believed to have reached the 6.1 million barrel level . . . The 1956 crude production is estimated to have amounted to less than 1.3 million barrels.

HUNGARY: In a gradual production increase after the recent rebellion, 116 wells are producing in Zala county, yielding about 2600 barrels of oil daily.

ISRAEL: Heletz 16, northernmost well drilled in the nation's only field, is slightly lower structurally than the highest well, No. 7, indicating that the northern limit of the field may now be near definition.

LEBANON: Crude oil delivered from Sidon during January amounted to an average of 307,936 barrels per day, the Trans-Arabian Pipe Line Company has announced, in comparison with 313,474 barrels a day during January, 1956.

PAKISTAN: Attock Oil Company reported total 1956 production of an average of 3914 barrels a day as compared with 3800 barrels daily in 1955, with most of the increase in production credited to Dhulian field . . . A deep test north of Dhulian had reached 9494 feet in search of the Ranikot zone . . . Almost one-fifth of the 217-mile Sui-Multan natural gas transmission line has been completed . . . Drilling was continuing at the Pakistan Petroleum test well on Drigh Road in Karachi which was last reported drilling ahead at 8123 feet without oil shows.

POLAND: It is reported that the recent Hungarian rebellion resulted in a shortage of liquid fuel . . . Also, it is claimed that the 1956 production

Canadian Reserve Figures Reach New Heights in '56

Canadian operators proved up record oil reserves again in 1956, also a year of record crude production. This information highlighted the recently released report on reserves by the Canadian Petroleum Association.

Canada's reserves of crude oil and natural gas liquids increased almost 373 million barrels to a new peak of more than 3.1 billion barrels. Operators developed more than 544 million barrels of new reserves while producing almost 172 million barrels. The continuing pace of Canadian operations is reflected by a comparison of 1956 reserves and production with 1955, when 470 million barrels of new crude reserves were developed while production for the year amounted to 130 million barrels.

Reserves of liquid hydrocarbons in Canada at the end of 1956 were estimated at 3,129,304,000 barrels, up 372,685,000 barrels from the previous year. New reserves proved during 1956 totaled 544,662,000 barrels, with production of 171,977,000 barrels.

Estimated Proved Reserves of Liquid Hydrocarbons in Canada

Source: Canadian Petroleum Association

Thousands of Barrels

PROVINCE	Proved Reserves Dec. 31, 1955 (1)	Added in 1956 by Extensions and Revisions (2)	Discovered in 1956 in New Fields and in New Pools in Old Fields 1956* (3)	Production During 1956 (4)	Proved Reserves Dec. 31, 1956 (Columns 1+2+3 Less Column 4) (5)	Changes in Reserves During 1956 (Column 5 Less Column 1) (6)
Crude Oil						
Northwest Territories	53,707	.....	.....	449	53,258	—449
Alberta and British Columbia	2,169,985	344,213	19,721	142,141	2,391,778	+221,793
Saskatchewan	236,872	113,711	28,394	20,284	358,693	+121,821
Manitoba	45,211	2,577	56	5,839	42,005	—3,206
Ontario and New Brunswick	3,759	465	20	608	3,636	—123
Total Crude Oil	2,509,534	460,966	48,191	169,321	2,849,370	+339,836
†Natural Gas Liquids	247,085	20,505	15,000	2,656	279,934	+32,849
Total Liquid Hydrocarbons in Canada	2,756,619	481,471	63,191	171,977	3,129,304	+372,685

*Limited area assigned to a discovery until proved larger.
†All natural gas liquids located in Alberta and British Columbia.

rate is estimated to be about 10 percent above the 1956 quota of about 2.7 million barrels; however, domestic production furnishes only about 10 percent of total annual requirements.

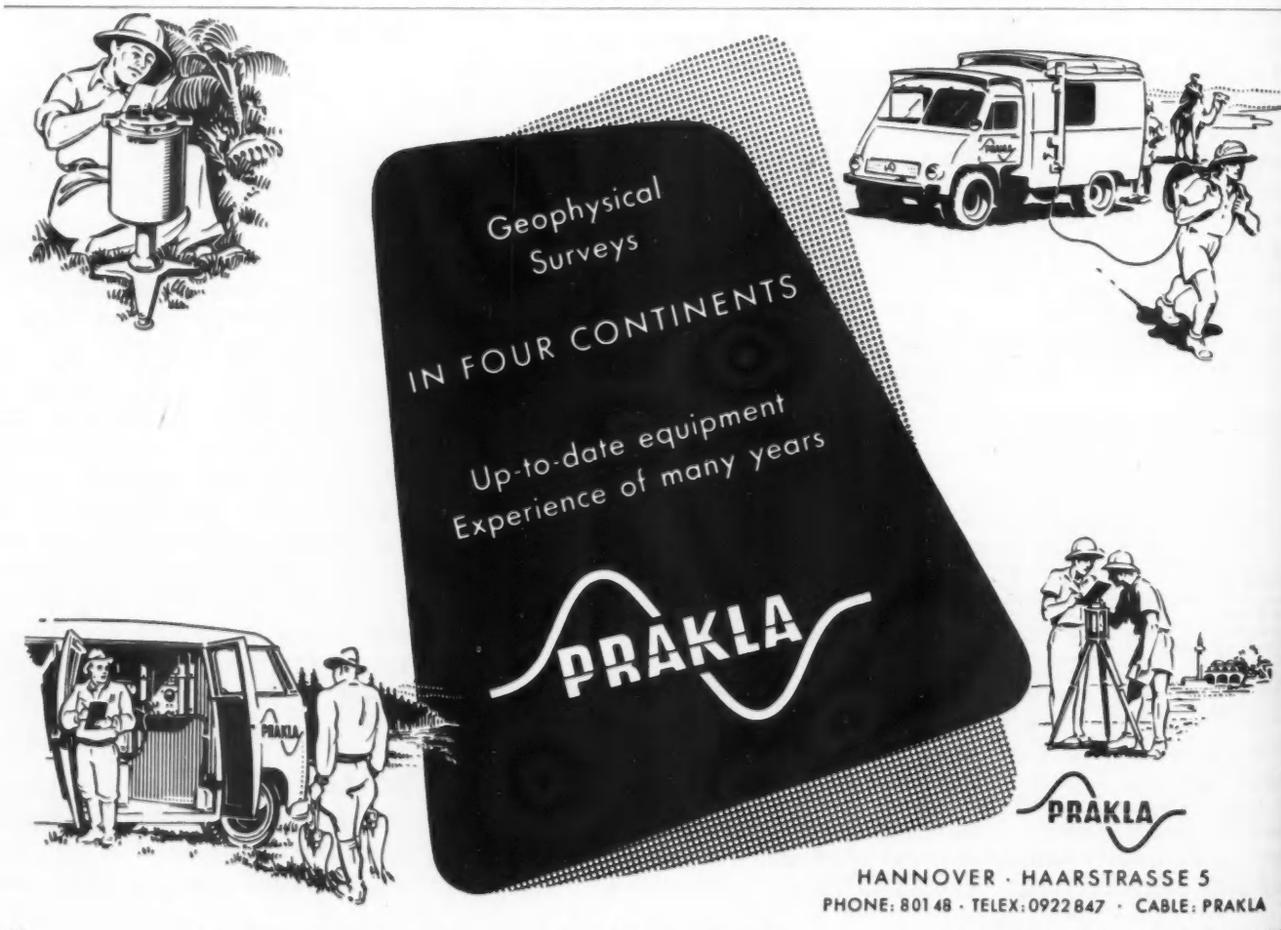
RUMANIA: Rationing of natural gas in this, one of Europe's richest oil areas, has been instituted . . . A new drilling depth record—11,719 feet—has been set at Moldova 4, which exceeds by 458 feet the former record.

RUSSIA: The second natural gas Stavrapol-Moscow pipe line, claimed to be the longest in Europe, has been commissioned. Length of the line is 807 miles . . . The 1956 crude production figure is believed to have exceeded the 1955 output of 1.4 million barrels daily by at least 200,000 barrels at day, with at least 58 percent of the total Russian yield stemming from the Ural/Volga districts . . . Napthaplin enterprise has begun a second well in the Drava River area of Croatia . . . Napthaplin also has drilled near Vucovar, a village on the south shore of the Danube River, and discovered two oil horizons—at 3415 feet and 3547 feet.

SAUDI ARABIA: Crude production during January totaled an average of

Standard's Aid to Hungary

Oil lends a helping hand as a husband and wife from Budapest join the first of the participants in the refugee aid program of Standard Oil Company (New Jersey) for former employes of MAORT, its expropriated affiliate in Hungary. Joseph T. Mantsch, right, of Jersey Standard, interviews Mr. and Mrs. Stephen Polonyi at the Hungarian Reception Center in Camp Kilmer, N. J. Polonyi, a draftsman, served MAORT for 14 years and will be assisted in obtaining employment when immigration processing is completed at the camp. Mantsch, who served with MAORT before its seizure by the Communist government of Hungary in 1948, is helping to administer the Jersey Standard program for former MAORT employes finding asylum in the U. S. Seven such refugees from Hungary now are participating in the emergency relief plan.



665,204 barrels a day, as compared with an average of 1,000,239 barrels per day during January, 1956.

YUGOSLAVIA: Negotiations are under way with Saudi Arabia for the purchase of Saudi Arabia crude during the second half of this year.

Israel Frees Oil Equipment From Duties and Taxes

Oil companies and drilling contractors operating in Israel now are exempt from payment of sales and excise taxes on such locally-produced materials as cement and tires bought for oil exploration and development.

This exemption, announced by the Israeli government, is contained in a new amendment to the country's basic Petroleum Law of 1952. The amendment also grants drilling contractors exemption from customs duties, which formerly was allowed only to companies holding oil licenses.

The new exemptions all are retroactive to April 1, 1954, the beginning of Israel's first complete year of oil development. Taxes paid since that date will be refunded.

This new amendment is the first comprehensive legislation dealing with all the tax exemptions available to drilling contractors and oil companies, which now can import or buy needed materials and equipment without duty, sales or excise taxes.

In essence, the new legislation means that all materials used for developing Israel's oil resources are free from government levy of any kind. It is part of continuing official encouragement of oil operations by private companies, which last took the form of a depletion allowance, formally enacted in August, 1956.

Currently, nine private companies hold oil licenses in Israel, seven either U. S. owned or with substantial U. S. investment, and one owned by Canadian interests.

Israel's current oil production, all from the successful Heletz field, is about 1000 barrels daily from eight wells, with work proceeding on 12 more. Drilling also is progressing at other sites throughout the country which geologists consider promising. These sites include Berer Hayil, adjacent to Heletz; Sodom, on the Dead Sea; and Beit Shean, south of the Sea of Galilee.

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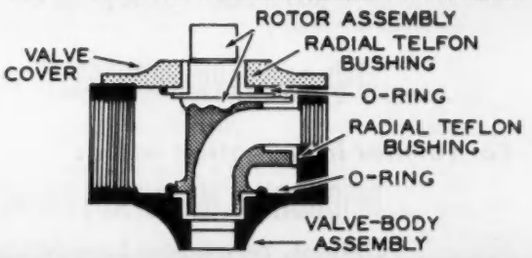

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8460 West Third St. Los Angeles 48, Calif.

Africa Success

Continued from Page 237

at the year's end. Two tests were completed on the peninsula just north of Dakar. Small quantities of gas and oil were recovered on a test at 1362 feet to 1404 feet in the Cretaceous in one of the tests. Upper Cretaceous structures about 30 miles east of Dakar were being drilled with encouraging shows being found in several wells.

Royal Dutch Shell and The British Petroleum Company interests are somewhat encouraged by two oil discoveries made during 1956 in Nigeria. At Afam, 20 miles east of Port Harcourt, a wildcat tested oil and gas and a second well, three quarters of a mile north of the first, was started late in the year. At Oloibiri on the Niger river delta, three wells had encountered oil at moderate depths by January, 1957, and the rig was being moved to Oloibiri 4, slated for completion in March.

Farther north, a new well at Akukwa, in Onitsha Province, was being drilled in hopes of finding oil associated with high-pressure gas that caused a blowout when the first well on this structure was drilled below 12,000 feet in 1955. Shell-D'Arcy Petroleum Company of Nigeria Ltd. expected to determine by drilling whether the Oloibiri find is worth the $14 million in production, pipe line, and tanker-loading facilities estimated to be necessary to put the field on production.

French Equatorial Africa. But no such uncertainty existed in French Equatorial Africa, where Societe des Petroles de L'Afrique Equatorial Francaise (SPAEF) had found oil fields at Point Clairette near Port Gentile and at Ozouri, 20 miles further south, also near the coast. Coastal French Equatorial Africa is salt dome country. Reportedly 100 salt domes have been proven to exist in the area from drilling and/or geophysical data. Discovery of Ozouri field was made in 1955.

During 1956, SPAEF completed nine wells at Ozouri and five at Point Clairette. Of these, seven indicated for production at Ozouri and all five at Point Clairette were reported successful. There are a number of pays in the Eocene and Cretaceous. Point Clairette 2, for example, tested 31 gravity crude at the rate of 157 barrels per hour from 3195 to 3248 feet. Another pay found from 3596 to 3672 feet tested 151 barrels per hour. Point Clairette 3 tested seven barrels per hour of 19 gravity oil at 2927 feet in the Eocene, then tested 163 barrels per hour at 3947 feet in the Cretaceous. Clairette 5 encountered two pays in the Eocene and three more in the Cretaceous.

Reserves of these two multiple pay fields obviously are substantial. And exploration prospects in the vicinity are bright, what with so many salt structures having been indicated.

Tankers are being loaded at Cape Lopez to transport Gabon-produced crude. Total 1957 production from French Equatorial Africa is estimated at about 2.2 million barrels by Le Journal des Carburants, or about 6000 barrels per calendar day.

A crude pipe line has been completed between Ozouri and Cape Lopez.

Angola. A second oil discovery occurred in 1956 at Luanda, following the 1955 discovery of Benefica field about 22 miles south of Luanda, near

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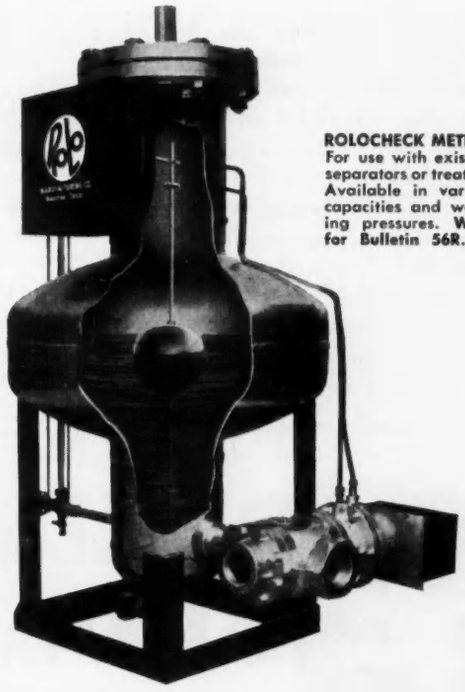

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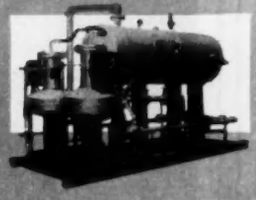

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the Atlantic Coast. By the end of 1956, Companhia de Combustiveis do Lobito, Petrofina affiliate operating in Angola, had completed five wells to depths of 8400 feet or deeper in the Benefica field.

Luanda 2, the discovery well of the most recent find, found prolific Albian-age (middle Cretaceous) limestone production at 5580 feet. Production tests were as follows:

1. 500 barrels per day on a 11-millimeter choke
2. 860 barrels per day on a 13-millimeter choke
3. 3000 barrels per day on a 25-millimeter* choke

The Luanda field will be developed more fully during 1957. A vigorous wildcatting program to prove up more of the numerous indicated structures is in progress.

Some limited production of Angola crude has taken place since May, 1956. In September, 1956, crude oil shipped to Portugal from Angola amounted to 4250 tons, or almost 30,000 barrels.

* A 25-millimeter choke would be almost 1-inch in diameter.

—The End

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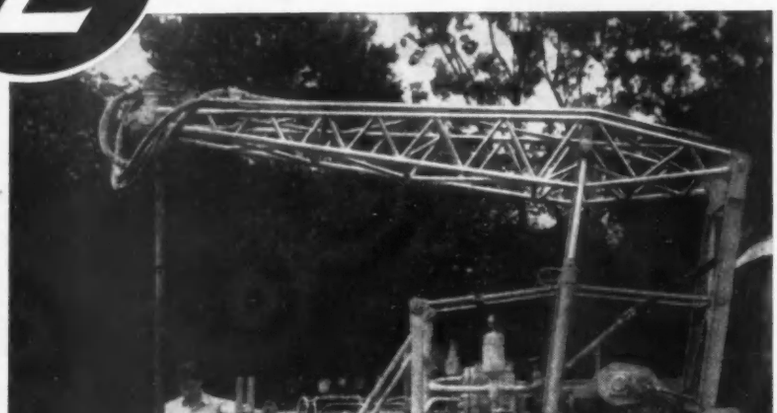

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A guide mounted vertically under the rotary head, and a short distance above the ground, holds the first length of drill pipe, and the bit, vertically and prevents the turning bit from wandering at the commencement of the hole. As drilling progresses the guide serves to reduce whip in the drill string and so assists in maintaining the drilling of a straight hole. Send for illustrated bulletin.

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Saudi Arab Field

Continued from Page 239

All but 28 miles of the line is being buried, but in the *sabkhah* areas, steel supports were driven deep into the ground by a pile driver. These supports were then capped and installed with ring girders to hold the pipe in place about two feet above the ground. Corrosion problems would be very severe in *sabkhah* areas should pipe have been buried there.

Despite the *sabkhah* problem along the coastal route, the advantages of this route outweighed the liabilities. As is apparent from the map, the coastal route is 55 miles shorter than the inland route.

Offshore wells and emplacements at Safaniya will have cathodic protection, for the Persian Gulf waters, ranging in temperature up to 90 degrees, are highly corrosive. In addition, the pipe line platforms and main gathering line are proposed to be monel-clad through the splash zone, but the offshore well platforms and flow lines from them are not so clad.

Work on offshore drilling platforms and gathering system at Safaniya was 65 percent complete by the end of 1956. The main gathering line is 16-inch diameter, the flow lines six-inch, comprising a total of about 40 miles of submarine pipe lines at Safaniya.

A gas-oil separator plant is being constructed immediately onshore at Safaniya at the apex of the gathering system. The gas oil ratio of Safaniya wells is ony about 90 standard cubic feet per barrel, as compared with about 600 to 900 standard cubic feet per barrel ratio of most Saudi Arabian oil wells farther south.

It is possible that diesel pumping units may be used initially at Safaniya temporarily. Aramco suffered the misfortune of seeing the ship *Lemsterkerk,* bound for Ras Tanura with three 900-hp gas turbine pumps and 15,000 feet of 22-inch pipe, trapped in the Suez Canal during the recent hostilities. It was freed to return to the Mediterranean in early January and was expected to arrive at a Persian Gulf port early in March.

Despite the delay, Aramco officials

hoped to complete the new line in May. The three small turbines were expected to be installed at Safaniya to represent the primary pumping station. They will burn natural gas produced with the oil at Safaniya. Selection of these prime movers was made on the basis of a need for maximum power coupled with minimum maintenance. Future plans for a second pumping unit at the approximate midway point of the line, not far from the newly-discovered Khursaniyah oil field, are indefinite but will probably involve turbines—either a battery of small turbines or one large turbine pump in the order of 5000 hp. Whereas natural gas will be burned in the turbines at Safaniya, crude oil would fuel the secondary pump unit. This operation will involve corrosion problems, as the temperature range within the turbines will be in the order of 1200 degrees and residual ash, particularly vanadium, would be troublesome. Chemical corrosion inhibitors apparently will be required in the case of the secondary pump unit.

Aramco has experimented with crude-burning combustion turbines to generate electricity in Saudi Arabia, and Tapline is now installing 5000 hp crude-burning turbines at five points as part of its plan to increase capacity.

The pipe used for the Safaniya-Ras Tanura line is 22-inch OD, seamless with ¼-inch wall over the entire line with the exception of the last five miles at the refinery end. For added safety, the pipe used over the short terminal stretch has a 5/16-inch wall thickness. The pipe for this project was purchased in Western Europe. Since most of Aramco's oil is sold in Europe, the company's equipment and supplies are purchased there when feasible. About 21,000 tons of pipe is going into the project.

Most of the first increment of Safaniya crude probably will be refined in Saudi Arabia. After the line's output is expanded, much of its output presumably will be loaded directly into tankers and exported as crude.

In order to cut in half the amount of welding necessary along the route, a "double-ending" yard was set up at Ras Tanura. There, 40-foot joints were welded into 80-foot lengths before being trucked to the right-of-way. Each section weighed two and one-

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History of the Seismograph
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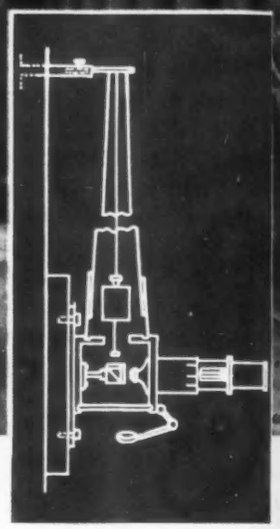

Microseismic disturbances *studied with vertical pendulum!*

Francisci Travagini, 1679, appears to be the earliest writer who believed that an earthquake is a pulse-like motion propagated through solid ground. He devised a pendulum whose tip terminated in loose sand or ash which would describe trails in the sand associated with the movement of the earth.

However, Father Timoteo Bertelli, 1870, of Florence is credited with being the founder of systematic microseismical research. Depicted here is Bertelli making observations through his Normal Tromometer. This instrument (shown in cutaway drawing) consisted of a vertical pendulum 1½ meters long carrying, by means of a fine wire, a weight of 100 grams. To the base of the bob a vertical stile is attached, and the whole is enclosed in a tube, terminated at its base by a glass prism which permits viewing the stile in any azimuth. Inside the microscope a micrometer scale is so arranged that it can be turned to coincide with the direction of oscillation of the stile. In this way Bertelli made 5,500 observations on both the amplitude and azimuth of microseismic motions.

Modern microseismic recordings are made most efficiently on the magneDISC, disc-type magnetic recorder, an exclusive *Seismation* system developed by Texas Instruments Incorporated. The magneDISC, with its greater capacity for recording, storing and reading back of valuable seismic data, is used by leading seismologists the world over in their relentless search for oil.

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fourth tons. All welds, including those made in the field, were X-rayed to check for flaws.

At the refinery and terminal, four new 180,000-barrel tanks and the necessary piping were under construction to permit the handling of Safaniya crude. Terminal loading lines also had to be expanded to permit the handling of Aramco's increased productive capacity. —**The End**

Cuba's North Coast

Continued from Page 241

area was Acción 1. It is located approximately 2500 feet from the southern edge of the hill, south of Tina 1. Scout reports indicate the following section:

0 feet-850 feet—*Miocene*—limestone.

850 feet-1,650 feet—*?*—red shale *(?)*.

1,650 feet-4,025 feet—*Cretaceous (?)*—volcanics or serpentine.

The volcanics or serpentine in this well have the same lithology as in Tina 1. It was abandoned at the depth limit of the rig without having found salt.

Structure. The structural interpretation of the subsurface information is extremely difficult, especially since it has been made without the benefit of the complete information such as logs, maps, etc. The accompanying cross-section showing a dome is only one possible solution. Another interpretation would be to theorize that the salt is part of a northward thrust sheet. Thus, the top of the salt might exist at 5500 feet in Acción 2 and might overlie Eocene sediments in Tina 1 at about 11,500 feet. This would explain the nearly horizontal banding and crystal alignment, but would not fit too well with the sharp fold at the surface, nor with the gravity minimum.

However, the writer believes that the following points strongly suggest that this is a true salt dome:

- The sharp surface fold with the axis trending in a direction opposite to the regional strike.
- The gravity minimum which coincides exactly with the hill.
- The overhang found in Tina 2.

One very puzzling feature is that igneous rock is found only on the south side of the dome and Eocene limestones and conglomerates are found only on the north side. Another peculiarity is that the igneous rock is found 1320 feet higher in Acción 1, than in Tina 1. Faulting is not a logical ex-

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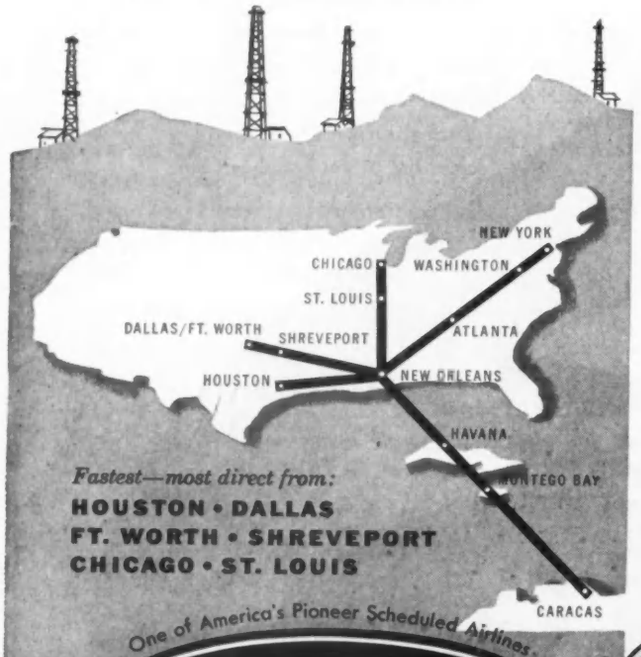

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planation since the upthrown block would be expected to be nearest the dome. A high relief unconformity surface has been theorized to explain this, but it may not be the correct interpretation.

Structural History. Assuming that this feature is a dome the structural history of the area is interpreted as follows:

1. Deposition of impure salt (Jurassic) covered by dolomite anhydrite and limestone (Upper Jurassic to Upper Cretaceous) in a northern facies. A central limestone facies and a southern volcanic-clastic facies are also known from field work on the mainland.

2. After deposition of the Upper Cretaceous, northward low-angle thrusting emplaced the volcanic facies over the limestone and evaporite facies. This sandwich of thrust plates was later cut by high angle reverse faults.

3. At the end of the orogeny a high relief unconformity surface was overlapped by Tertiary sediments.

4. Piercement of the salt must have occurred after deposition of the Miocene, since these beds form the flanks and core of the Cunagua Anticline. An old high-angle fault may have provided the zone of weakness along which the salt started upward, cutting through the evaporite facies, the overlying thrust of volcanic-clastic facies and finally the Eocene overlap.

Oil Prospects. Other untested gravity minimums occur in nearby areas of the north coast, and some coincide with more gentle surface highs. For this reason, it appears almost certain that similar structures do exist. It is expected that such structures will be found to have pierced a cover which consists for the most part of compact, hard limestone, dolomite and anhydrite.

In Shell, Cayo Coco 2, some dolomites were found to have excellent oil staining in intercrystalline and fracture porosity under impermeable anhydrite beds.

It is not suggested that Cuban salt domes offer as favorable an oil prospect as those in the Gulf Coast, which have pierced loosely consolidated clastics with abundant intergranular reservoirs. However, the writer believes that wildcats drilled on the basis of detailed seismic work around gravity minimums on the north coast of Cuba have good chances of finding the proper combination of structure and reservoir which may add up to a major oil field.

—**The End**

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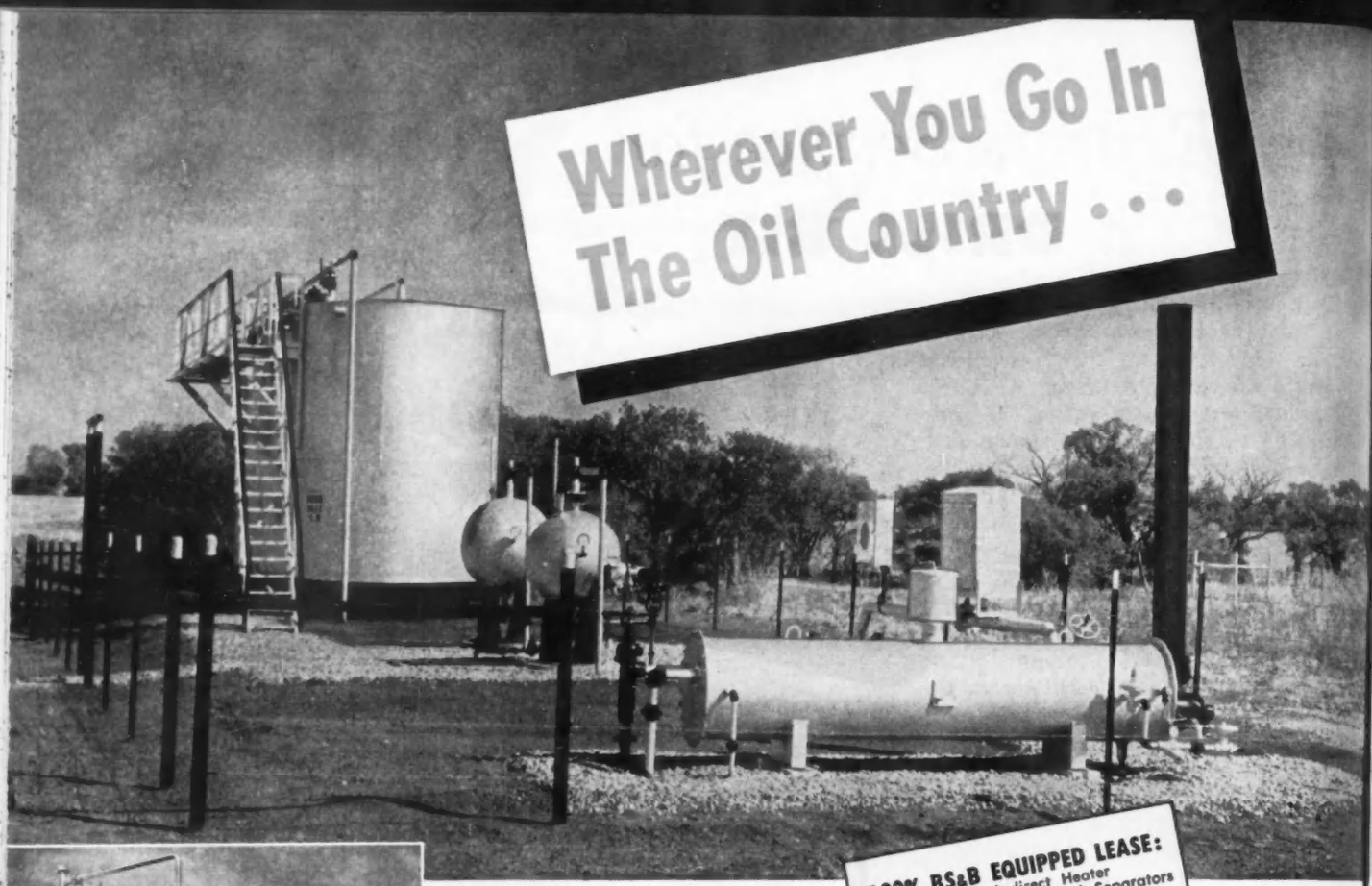

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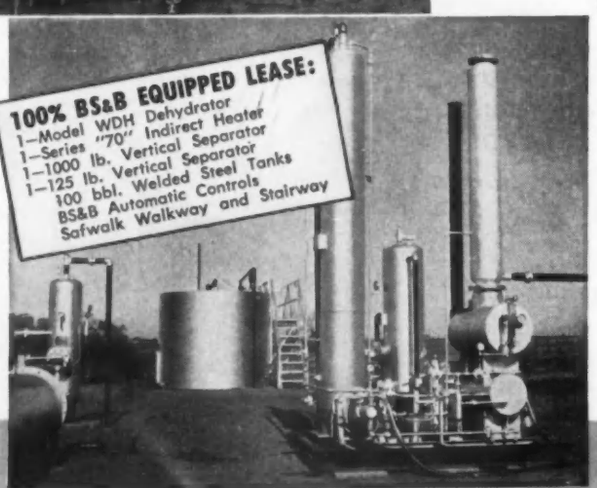

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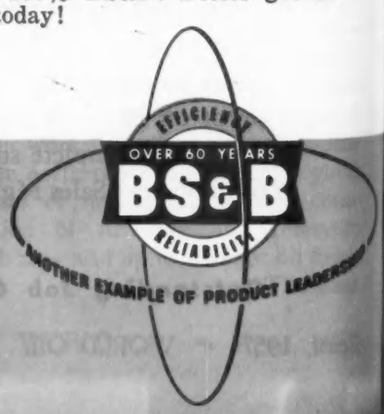

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Announcement Awaited On Second Venezuelan Grant

Several U. S. oil companies in mid-March were awaiting an announcement from the Venezuelan government on the second award of oil concessions. Bidding for the latest concessions was closed Feb. 11. Approximately $400 million was paid last year when Venezuela granted its first new concessions since 1945.

Mene Grande Oil Company, a Gulf Oil Corporation subsidiary; Shell Petroleum Company; Signal Oil and Gas Company; and Creole Petroleum Company, a subsidiary of Standard Oil Company (New Jersey) received a major share of last year's concession with high bids. These development concessions were on Lake Maracaibo, but exploration concessions in other areas were granted along with them.

It is expected that other regions of Venezuela will be included in this second granting of concessions. Also, companies expected to receive new concessions are Atlantic Refining Company, Cities Service Oil Company, Sunray-Mid-Continent Oil Company, Kerr-McGee Oil Industries, Inc., Phillips Petroleum Company, The Texas Company, Continental Oil Company and Creole Petroleum.

Union Oil Company Halts Panamanian Drilling

Union Oil Company has halted operations on its Panama concessions. Yorkin 1 well, near the Costa Rica border, was shut down after a depth of 5500 feet had been reached. Union officials said they have no immediate plans for further drilling in the republic.

The Yorkin 1 drilling rig was scheduled to be moved to Guatemala, where Union, jointly with several other companies, will conduct exploratory drilling.

Union also halted tests of its Cocolas 2 well in Costa Rica, and the well has been plugged. Officials said that the well, by itself, was not a commercial producer although last year it initially flowed at the rate of 1200 barrels daily. Cocolas 3 was spudded in during February in the same immediate area, near the Panama border.

What's Happening

AMONG WORLD OIL MEN

V. C. GEORGESCU has been named associate London Middle East representative by Standard Oil Company (New Jersey) and will serve the staff of P. J. ANDERSON, recently named to the newly-created post of London Middle East representative. In 1954 Georgescu became vice president and director of Near East Development Corporation, Jersey affiliate owning an interest in Iraq Petroleum Company, and has also been connected with Jersey Standard's seven percent participation in the Iranian Consortium.

V. C. Georgescu

Georgescu holds a B.S. degree in petroleum engineering and refining from Birmingham University in England (1925). He served as president and chairman of the board of Romano-Americana, Jersey's former Rumanian affiliate before it was expropriated in 1948. Since 1947 he has been associated with Jersey's Producing Coordination department in New York.

He was scheduled to move to London with Mrs. Georgescu in mid-March. Their two sons, Peter and Constantin, were to remain in schools in the U. S. The two boys were held as hostages in Rumania for a time while the Communist regime attempted to blackmail Jersey company secrets out of their father. Protests to the State Department by Georgescu resulted in such bad publicity for the Communists that the boys were finally released.

•

J. F. BLACKWELL has been transferred to the New York office of The Texas Company from Caracas, Venezuela, where he served as assistant manager (operations) of the Producing division of the company's Foreign Operations department, covering the Western Hemisphere and West Africa. He will fulfill the same duties in New York. Blackwell is a Texan, holds a B.S. in petroleum engineering from the University of Oklahoma (1933), and has been with Texaco since 1936.

•

C. N. BROOKS has been named general manager of The Texas Company's Foreign Operations department in New York, succeeding HARVEY CASH, who has recently become assistant to the chairman of Texaco. JOHN W. GREEN succeeds Brooks as manager of southern territory, Domestic Sales department in Houston. D. B. MONROE succeeds Green in Houston.

C. N. Brooks

•

DR. ENRIQUE T. MAURI, formerly exploration manager for Yacimientos Petroliferos Fiscales Bolivianos, Bolivian government oil company, has opened geological consulting offices in La Paz, Bolivia. For the past four years, Dr. Mauri has been with YPFB, where he was chief geologist from 1952 to 1954 and exploration manager from 1954 until his departure.

Prior to that, he had worked for YPF in Argentina, where he attained the position of chief geologist of the Northern district in 1949, a position which he held until 1952.

•

G. I. LEWIS was recently appointed Calgary division exploration manager for Shell Oil Company, succeeding L. A. LEWIS, who has been transferred to the company's head office at New York. Lewis returns to his appointment after two years on special assignment in The Hague and New York. A Welshman by birth, Lewis attended the University of Wales, graduating in geology in 1938. He worked as resident geologist with the Burmah Oil Company in India and joined Shell Oil in Calgary in 1949.

More and more

DRILLING HINTS

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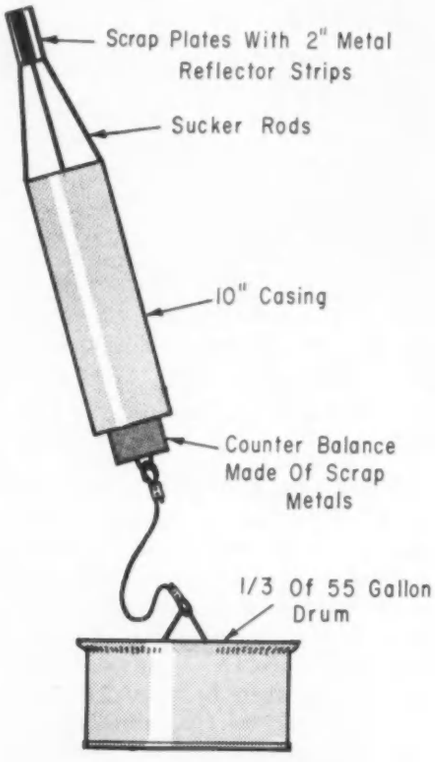
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With offshore drilling and marsh drilling progressing to its present state where many channels must be dug and the center of the channel marked, this aspect of the operation can become quite costly.

Channel marking is usually only half done in difficult areas because of the expense of the buoys. One simple solution to this problem is to use heavy casing as the body of the buoy and seal off a 6-inch section of this casing. The buoyancy is balanced by attaching a scrap metal weight to provide an anchor hold and also to weight the bottom of the buoy. Weld a 3-foot tripod to the top of the buoy and weld 4-inch by 12-inch plates to this extension. Place 2-inch reflector strips of metal on each plate. Anchor this buoy in place with a cable or chain. Make the anchor of a third, or a half, of a 55-gallon drum that is filled with scrap iron and cement. Paint the finished buoy with primer and enamel.

A comparable buoy would cost approximately $250. The cost including labor of making these home-made buoys is about $30 each.

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Into each of these sockets is run a fabricated pre-cut length of 2½-inch tubing, the outer end terminating in a vertical "T" of similar material. A short pipe leg, held in place by a set screw, the latter permitting adjustments for irregularities of ground, completes the support. Some half-dozen of these supports on each side of the pump provide the joists upon which a 2-inch plank flooring can be laid.

The resulting platform improves working conditions for the crew, speeds up liner changes and other routine work on the pump. Rig time saved through its use more than offsets the slight amount of time required to rig the platform, the latter being erected, for the most part, after surface hole is started.

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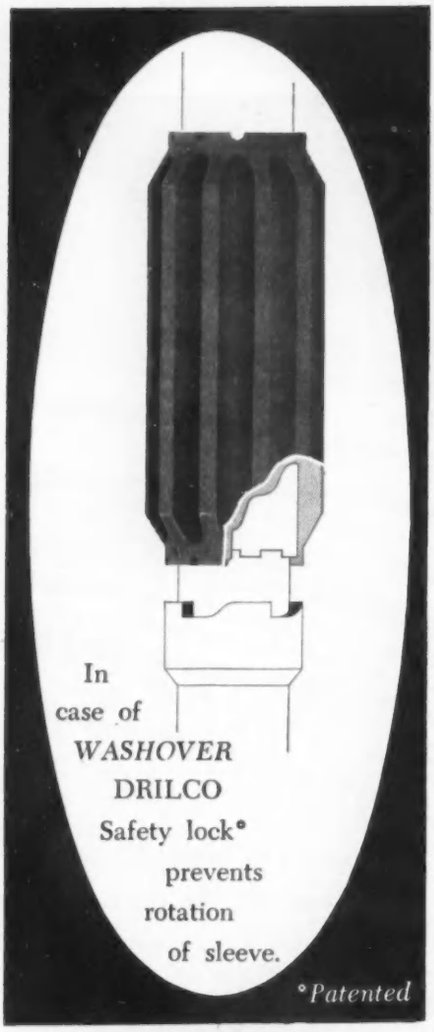

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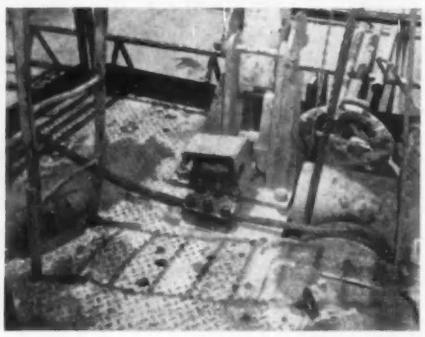
DRILLING HINTS . . .

moving the valve pot lids. This can be accomplished by the use of a mechanic's stethescope.

This instrument resembles a physician's stethescope in appearance only. It costs only a couple of dollars and is five times as effective as a screw driver or other home-made device that is sometimes used to listen for the source of trouble. This tool can easily be carried in the tool box on a power rig and may save a considerable amount of time lost from tearing into the wrong valve pot.



Protect Floor Level Clamp With Heavy Box-Like Cover

The time involved in slipping or pulling over a new drilling line is reduced by the wire line clamp and cover used by one contractor. Mounted at derrick floor level, the clamp easily is accessible and the man operating it can see the driller and watch for his signals.

At that location, however, the clamp is subjected to possible damage to threads or nuts through inadvertant dropping of heavy tools or equipment on it. To avoid possible injury, make a shopmade heavy box-like cover to slip over the clamp. Made of ⅜-inch steel plate, the cover has slots cut in it at opposite ends to permit the skirts dropping over the wire rope and resting on the floor.

The snugly-fitting cover also assures that the oiled or greased threads will remain so despite splashes of mud, chemical and frequent hosing-down of the derrick floor area.

Built-In Conveniences Improve Lube Oil Tank

A shopmade lube oil storage tank containing built-in provisions for completely draining each compartment, preventing accidental damage to gates

GREATEST ADVANCEMENT IN SWAB HISTORY!

The Oil States Swab is the most advanced swab on the market having been developed and perfected after years of research, painstaking work and engineering skill. It's acceptance has been overwhelming.

HERE ARE THE FEATURES YOU WANTED

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★ Only 6 parts Required to Assemble a 2-Cup Swab

SOLD THROUGH SUPPLY STORES EVERYWHERE

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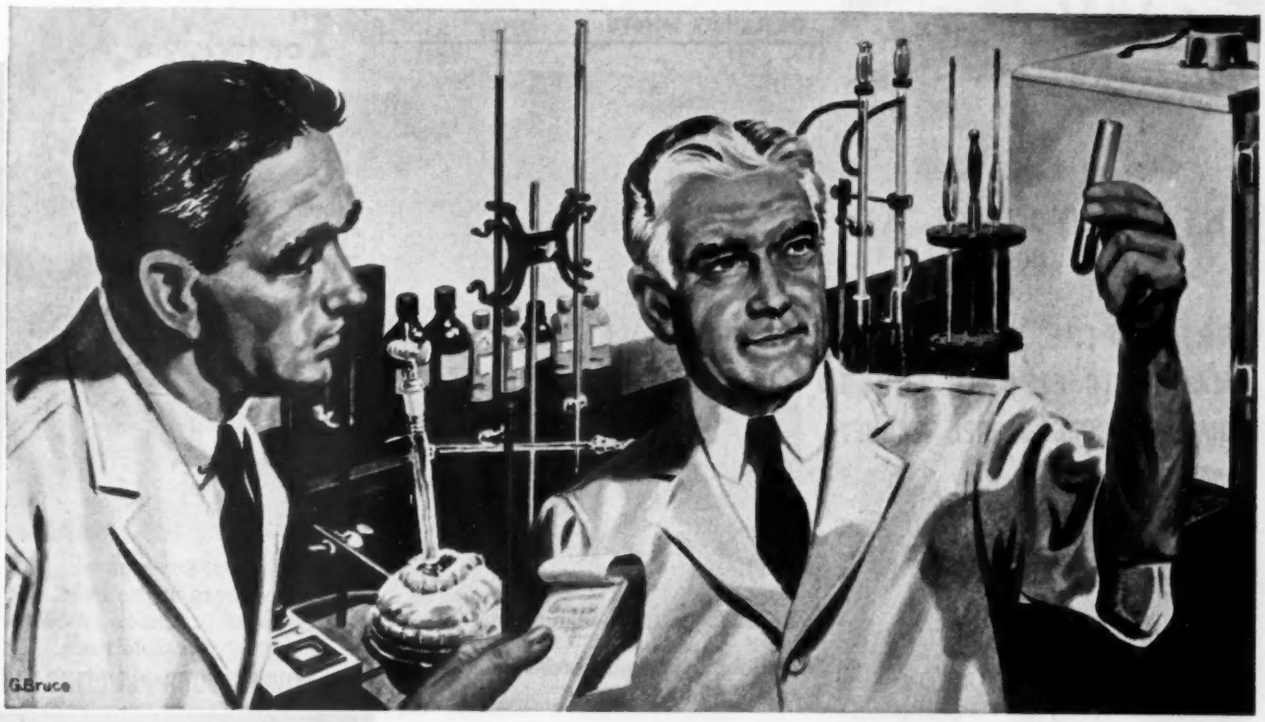

ELIMINATING CONDITIONS DANGEROUS TO EMPLOYEES

As part of its never-ending effort to improve its service to employers in Texas, the Texas Employers' Insurance Association maintains one of the most complete Industrial Hygiene laboratories in the Southwest. Generally analyzing elements and compounds used by industries . . . Identifying unknown materials . . . Determining flash and fire points of hazardous substances . . . Analyzing the very air workers breathe to prevent occupational diseases . . . These are but a few of the activities carried on in this laboratory to help Texas industries discover and eliminate conditions dangerous to the health and safety of their workers.

This is one of the many services offered by the Texas Employers' Safety Engineering Division. It's only one of the methods of ensuring safer working conditions and reducing accident costs. And it is one more reason Texas Employers' is the undisputed leader in the field of Texas workmen's compensation insurance. Are you taking advantage of the **SERVICE** and **SAVINGS** offered by Texas' largest writer of this coverage?

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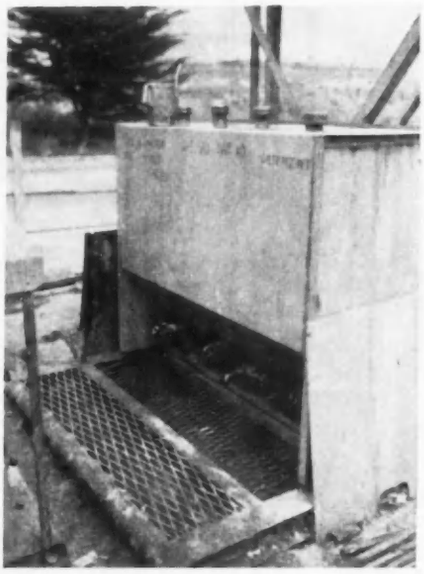

and eliminating hazards caused by accumulations of oil drippings, will pay for itself in a short while. These features, combined in the unit illustrated in the accompanying photograph, require little more work in the construction than a conventional rectangular flat-bottom tank.

A sloping bottom, protected on either end by a heavy skirt that extends down to the base, provides not only complete draining of compartments, but provides a sheltered area for the gates. Instead of using sheet for the floor, heavy expanded metal having sufficient strength to support a man without sagging is used to cover the area in front of and below the tank. Drippings that do occur then fall directly to the ground. Hazards of slipping thus are avoided and clean-up work seldom is required at moving time.

The compact, skid-base equipped unit easily is moved and set up at each location.

Outside Tool Unit Saves Engine House Floor Space

To make more efficient use of the limited space available inside the full-enclosed, winterized engine house, one Canadian operator builds a unitized tool rack, work bench and supply drawers as a single unit, encloses it with sheet steel and mounts it on a light skid base so it can be set on a pair of supports slung outside the engine house enclosure.

Open only to the inside rig area, the unit fits snugly into the opening provided in the winterizing panel.

For today's competition . . .
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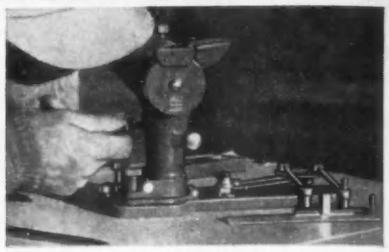
INSTRUMENTS



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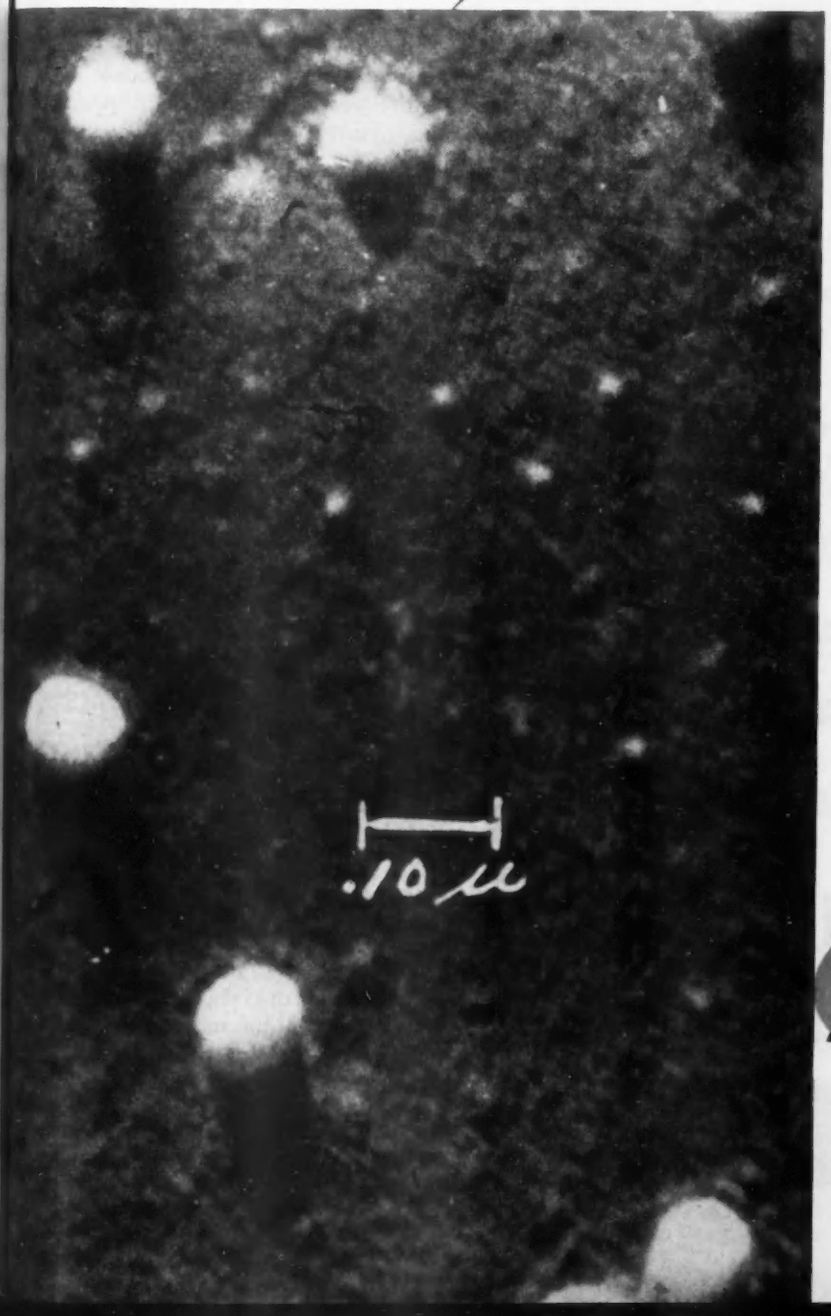
Influenza virus magnified 78,570 times by an electron microscope. The unit of measure shown, 0.1 μ, is 1/10,000 millimeter.



Tuboscope research in its field has been as imaginative and rewarding as the electron microscope has been in its field.

With instruments developed by Tuboscope research, Tuboscope technicians are able to measure the unseen ravages of wear, fatigue, and corrosion in oilfield tubular goods. These instruments, coupled with Tuboscope's years of experience, assure you of the best and the newest in proved methods of non-destructive inspection in the field.

The important elements of bottom hole temperature and pressure can likewise be measured by the Subsurface Engineering Division.

Tuboscope COMPANY

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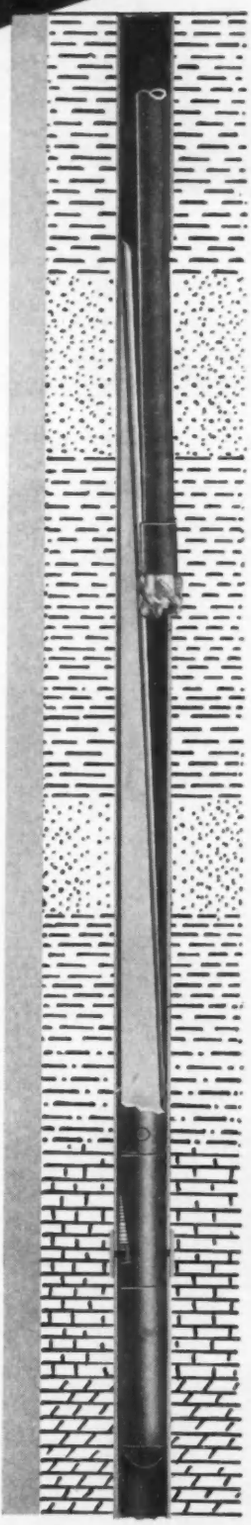
NEW KINZBACH SPEEDMILLS *Slash* DOWN-HOLE CUTTING TIME



UTILIZING TUNGSTEN CARBIDE PARTICLES that continuously renew their cutting edges, new Kinzbach Speedmills offer you faster, surer milling under even rugged down-hole conditions. Because of their extreme hardness, they require fewer replacements . . . fewer round trips.

Kinzbach Speedmills require less torque for cutting . . . eliminate drill pipe wind-up . . . reduce shock on drilling string. They retain their high strength and hardness at elevated temperatures and are unaffected by heat generated by cutting action. Most important, the close control of speed and weight necessary in ordinary subsurface milling operations is not necessary with Kinzbach Speedmills.

For faster cutting . . . surer cutting, be sure your next milling job is done with Kinzbach Speedmills. Types available for every down-hole cutting problem.

Type 154 Speedmill

TYPE 154 SPEEDMILL
This mill is designed for attachment directly to a Kinzbach Type H Whipstock as the first tool in progressive milling operations. After the Whipstock is set, the attachment bolt is sheared and milling operations can begin. The lug on the face of the Whipstock engages the tapered pilot of this mill, forcing it to cut through the pipe wall without thinning the top section of the Whipstock. The Model 154 Speedmill is used to cut the first two and one-half feet of window only.

Type 155 Speedmill

TYPE 155 SPEEDMILL
After the first stage of window cutting is completed, the Kinzbach Model 155 Speedmill is run to complete the window. This tool is designed to utilize cutting force reactions so that maximum length of window may be cut, while side blades are designed to resist reduction in gage diameter during operation.

Type 159 Speedmill

TYPES 156 AND 159 SPEEDMILLS
For general and milling operations. Used to mill up pipe or tools in the well and to shape the ends of obstructing materials for subsequent fishing operation.

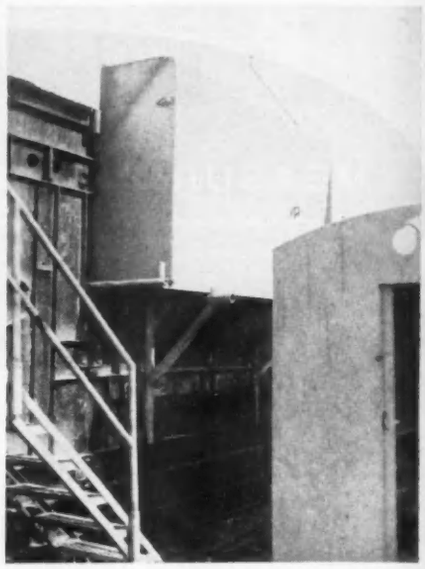
Type 156 Speedmill

KINZBACH TOOL CO INC

Export Office:
74 Trinity Pl.
New York, N. Y.

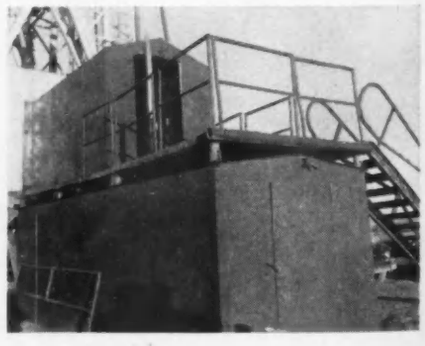
KINZBACH TOOL CO., INC., P. O. BOX 277, HOUSTON, TEXAS

DRILLING HINTS . . .



The two sturdily-braced brackets, made of salvaged tubing, are slung on hooks welded to the outside surface of the sub-base; a U-shaped cradle device holding the lower end of each of the vertical members in position and preventing sideways movement. Depending upon the size of the unit, such an outside-rigged work bench saves anywhere from 20 to 30 square feet of floor space; space badly needed for walkways and access areas for engines, drive group, auxiliary equipment, space heaters and gear that must be kept inside the fully-enclosed rig area.

Equipped with lifting eyes, the unit is easily moved and set up at rig moving time.



Disc Automatically Closes Dog House Latch Opening

Access to the inside latch of the rig dog house or change house is made easy by the unique method devised by one Rocky Mountain area drilling contractor. Of particular value during winter operations, or at night when the air is cold, the idea consists essentially of cutting a round hole in

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The cheapest and most dependable power in the oil producing business has always been provided by the horizontal, two cycle, crosshead type gas engine. This was true for the old-timers and it's true today. The only difference is in the engines!

Today's Ajax Gas Engine is a highly-engineered, precision product. Retaining all the essential simplicity of its great prototype, the Ajax you buy today is a product of the best design, the finest craftsmanship and the most suitable materials it is possible to obtain.

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the door adjacent to the inside latch and covering it with a round disc which, though easily thrust aside, always falls back to cover the opening after the man's hand is withdrawn.

In the installations shown, the opening is about 8 inches in diameter and the disc an inch or two larger to allow for adequate covering of the hole. The pin holding the disc is made to allow a certain amount of lateral play to permit easy thrusting aside of the round plate. If necessary to lock the dog house when left unattended at a rig site, a pin lock device easily could be welded to the interior to prevent the disc from being moved from the outside.

Overhanging Hoist Support Speeds Tool Handling

Loading and unloading heavy equipment at the tool dock can be speeded and the work made easier by constructing a horizontal bar which overhangs, by several feet, the edge of the dock. Illustrated in the photograph, the rack device is completely demountable, breaking down into six pieces for easy rigging at moving time.

Insert the two vertical members in sockets which are part of the dock structure. Several feet above dock level, weld a pipe socket to each post at such an angle that when the extension members are inserted, and the horizontal bar placed atop them, the bar will extend several feet beyond the vertical projection of the dock

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100% NYLON COMPOSITION

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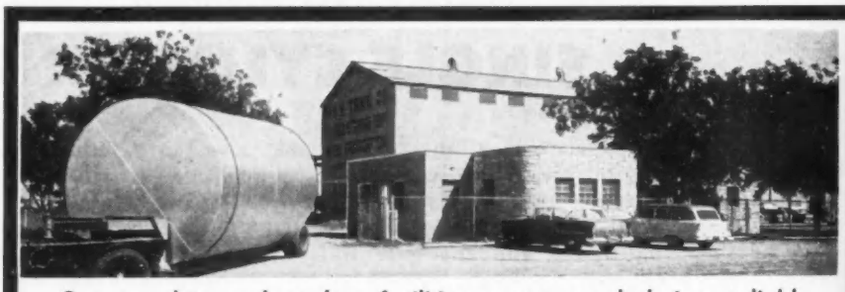

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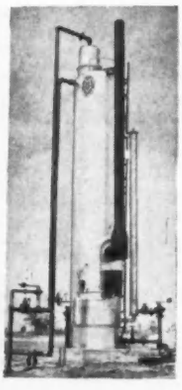

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Outstandingly efficient and trouble-free—designed for pressure operation as oil and gas separator, treating unit, and settling tank. Stocked for immediate delivery in sizes 4′ x 21′, 5′ x 21′, 6′ x 21′, 8′ x 21′.

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Dorrco D-Sander Available in Three Standard Sizes . . .

Mud Capacity
(at 20 psi operating pressure)

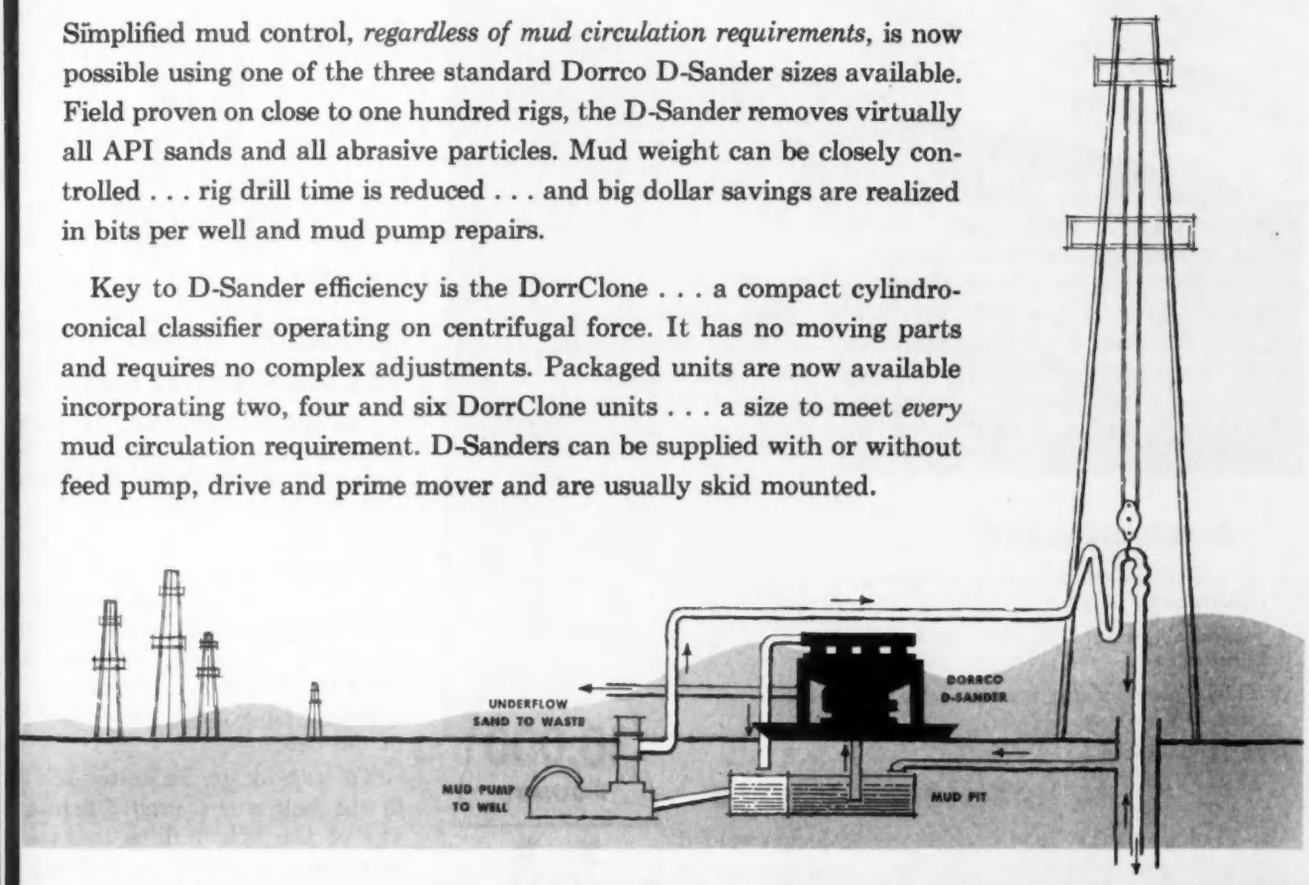
#2 D-Sander — 200-250 gpm

#4 D-Sander — 400-500 gpm

#6 D-Sander — 600-800 gpm

Simplified mud control, *regardless of mud circulation requirements*, is now possible using one of the three standard Dorrco D-Sander sizes available. Field proven on close to one hundred rigs, the D-Sander removes virtually all API sands and all abrasive particles. Mud weight can be closely controlled . . . rig drill time is reduced . . . and big dollar savings are realized in bits per well and mud pump repairs.

Key to D-Sander efficiency is the DorrClone . . . a compact cylindro-conical classifier operating on centrifugal force. It has no moving parts and requires no complex adjustments. Packaged units are now available incorporating two, four and six DorrClone units . . . a size to meet *every* mud circulation requirement. D-Sanders can be supplied with or without feed pump, drive and prime mover and are usually skid mounted.



For more information on the Dorrco D-Sander, contact our U. S. Sales Representative, Salt Water Control Inc., 1211 Fort Worth National Bank Building, Fort Worth 2, Texas.

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grating
PAT. PENDING

Realizing the need for an improved heavy duty, open steel floor grating of greater strength and economy, The GLOBE Company presents GOLD NUGGET Welded Grating — the first grating to take advantage of modern engineering design. As a result of this improved design, the GOLD NUGGET primary load bar provides 22% more strength with 14% less weight. The primary load bar is a miniature I-beam with all of the advantages of a true structural member.

GOLD NUGGET Welded Grating is recommended for power houses, loading docks, oil refineries, fire escapes, drain grates, plating rooms, filtration rooms and for all types of heavy duty platforms.

GOLD NUGGET

- ★ 3/8" projection weld nugget for greater rigidity and strength
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- ★ all bars are load carrying bars including secondary bars
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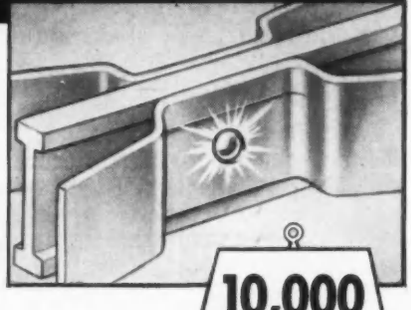

PROJECTION WELD

Each secondary load bar (A), as projected welded to the primary load bar (B) has a shear strength of 5,000 pounds per weld. There are 28 such projection welds to a square foot of grating. This means that GOLD NUGGET Welded Grating can sustain greater shock loads than other gratings.

For the complete details of this revolutionary new grating, write for new catalog today. Distributors in all principal cities. Consult the yellow pages in your phone book under "GRATING."

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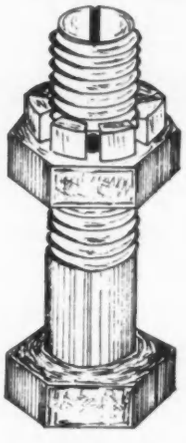
edge. Use another horizontal bar, fitted with similar sockets that slip down over the tops of the vertical posts, for lifting or swinging in loads that are farther back on the dock.

The chain hoist can be slid along the bar in either direction to accommodate materials spotted in different parts of the dock or truck bed. Simple in construction, it requires only scrap tubular materials and the time of a welder to adapt such a rack to the tool dock of any rig.



Cut Groove in Bolt To Locate Cotter Key

Due to the vibration of various machines, it is often necessary to lock a nut on a bolt. This is done in several different ways, but there is a lot of preference for the slotted castle nut and cotter key arrangement.

Whenever this type of bolt and nut is used, especially if they are in a out-of-the-way or unhandy place, it is often difficult to line the slots in the castle nut up with the cotter key hole in the bolt.

To help locate the cotter key hole in the bolt, cut a groove across the top of the bolt with a hacksaw or mark with a chisel to indicate the direction of the hole. When the nut has been made up sufficiently tight, line up the slots in the castle nut with the notch or groove that has been cut across the top of the bolt, and the insertion of the cotter pin can be made quite easily.

This arrangement greatly facilitates the use of these types of bolts where they must be made up at night or if they are greasy, or in tight or out of the way places.

For more data on advertised products, use Readers' Service Cards, last page.

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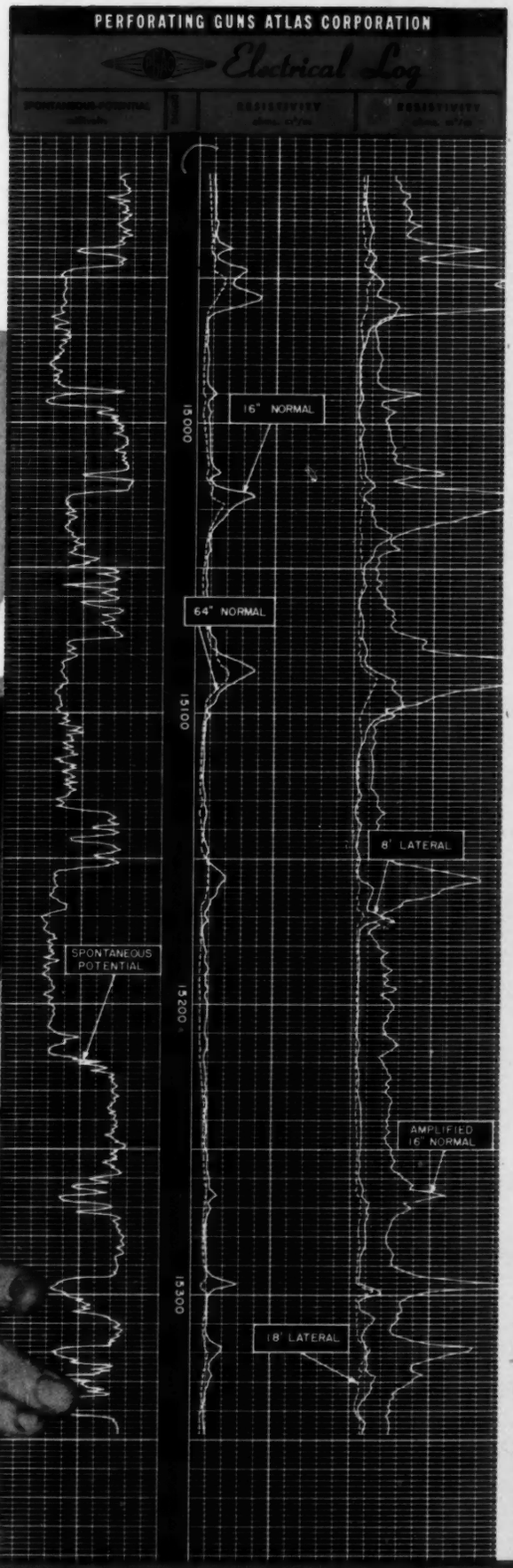
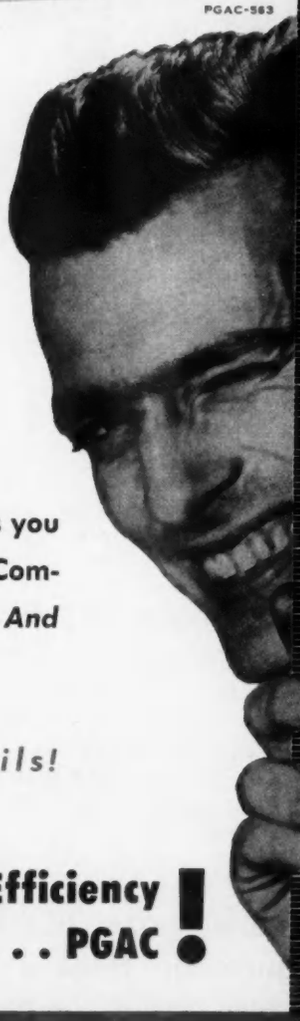
the BIG DIFFERENCE to YOU is the FIELD-PROVEN SUPERIORITY of PGAC's Electrical Log

PGAC-563





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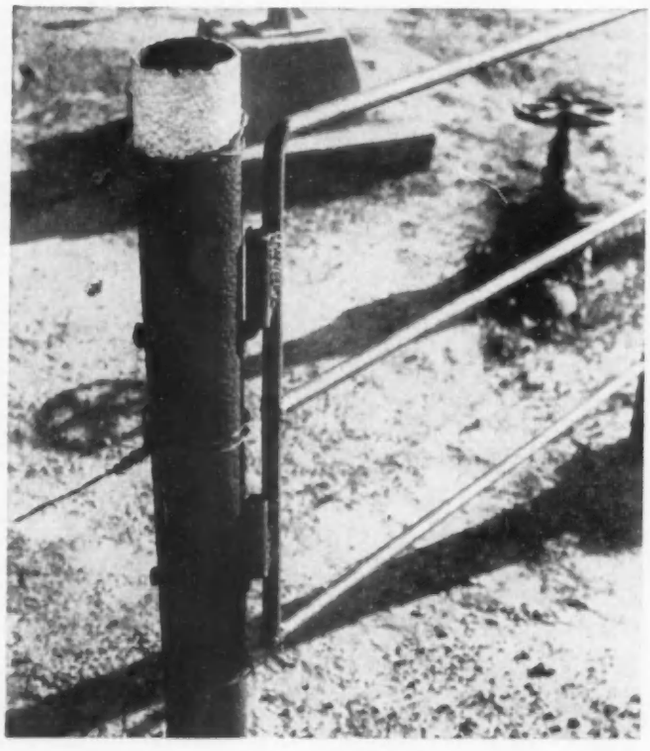
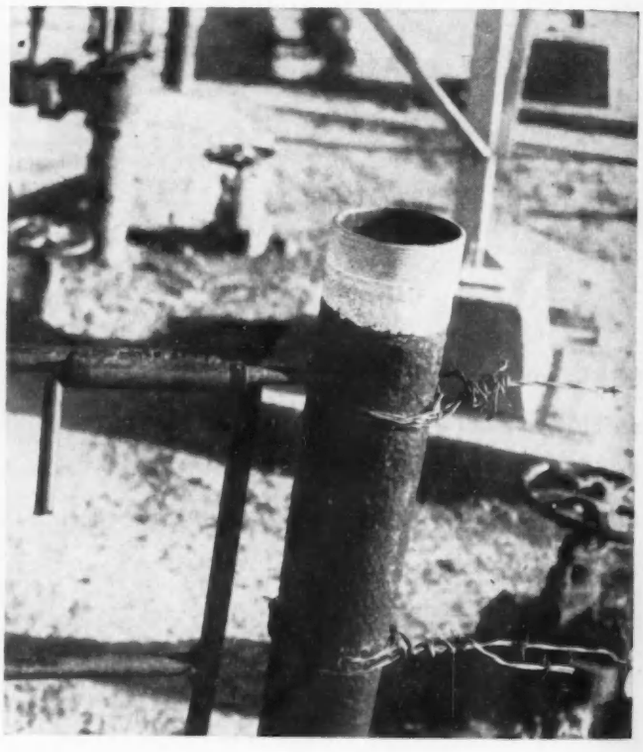




Make Simple Gate Fittings From Pipe and Steel Rod

Simple fittings for lease gate hinges and a locking device for a lease gate are no problem in the installation shown here. Cut some ¼-inch pipe to 6-inch lengths and weld to the gate. Drill two ½-inch holes through the post supporting the gate. Slip ½-inch bolts through these holes and bend 90 degrees. Insert the bolts in the pipe nipples and the hinge is complete.

The locking bolt consists of a piece of ½-inch steel rod in which a 90 degree bend has been placed four inches from one end. Place the rod through the pipe nipple so that it extends in a 1-inch hole drilled in the post adjacent to the free end of the gate.

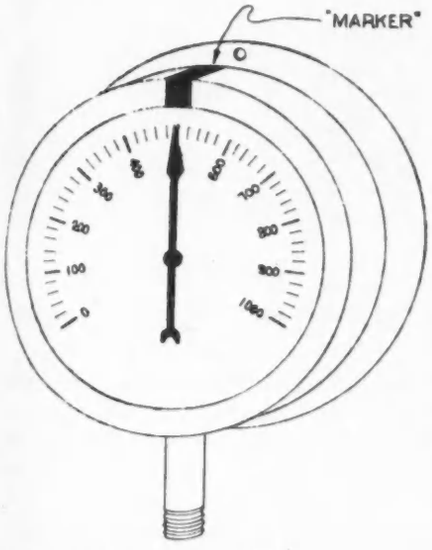
The entire system is extremely simple, costs little or nothing to install and yet performs satisfactorily under any conditions.

Remote Waste Oil Pit Reduces Fire Hazard

Keeping waste oil, particularly when it is high gravity, from accumulating in the cellar around the well head can benefit the producer in several ways: Danger of fire is reduced; there is less need for the expense and trouble involved in having a vacuum truck out to remove the accumulated fluids; and, when heavy rains occur, there is less chance of the cellar filling and overflowing, bringing the expense of cleaning up sludge and oil film that is floated out and spread over the surrounding area.

To the end that such accumulations of waste oil will be minimized,

one operator in the Denver Julesburg Basin attaches a 20-foot length of 1-inch pipe to his tubing head sample cock and, at the outer end, attaches a tee and nipple to direct fluid into a shallow pit. Now, when the pumper takes a sample and lets the fluid flow for a short while in order to get a representative flow line sample, the waste oil collects harmlessly in the hole. At intervals, when the wind is in the right direction, the pumper can burn the accumulated oil with little danger to the well or equipment. A clean and neat location results from this practice.



Use Waterproof Tape To Check Pressure

Here is a means to facilitate reading the pressure gages to determine if the operating pressure is normal. The range of the normal operating pressure for a particular application of a pressure gage is marked by fixing a piece of waterproof tape to the gage glass retainer rim in a position opposite the normal pressure range. If the gage is moved to another location, the marker is moved to indicate the normal operating pressure for the new location.

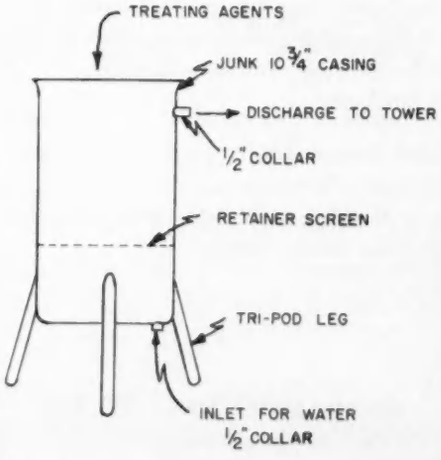
Marking pressure gages as proposed is very beneficial at locations such as tank batteries and well heads since employes other than the regular pumper are frequently required to check the gages. The marks facilitate checking the pressure gages for abnormal pressures and eliminate any doubt as to the normal operating pressure of the gage.

(Courtesy Humble Oil & Refining Company.)

Treat Cooling Water in Easy-to-Build Reservoir

For an improved method of adding chemical treating agents to the cooling tower water, construct a small reservoir of a length of 10¾-inch casing. Connect this reservoir to the main water supply line to the top of the cooling tower in such a manner that water will bypass through the reservoir.

The chemical treating agents are placed in the reservoir which permits the water passing through the reservoir to dissolve and disburse them at a uniform rate at the top of the cooling tower. This eliminates the necessity of climbing to the top of the cooling tower to disburse the chemical treating agents.



Use of this suggestion promotes

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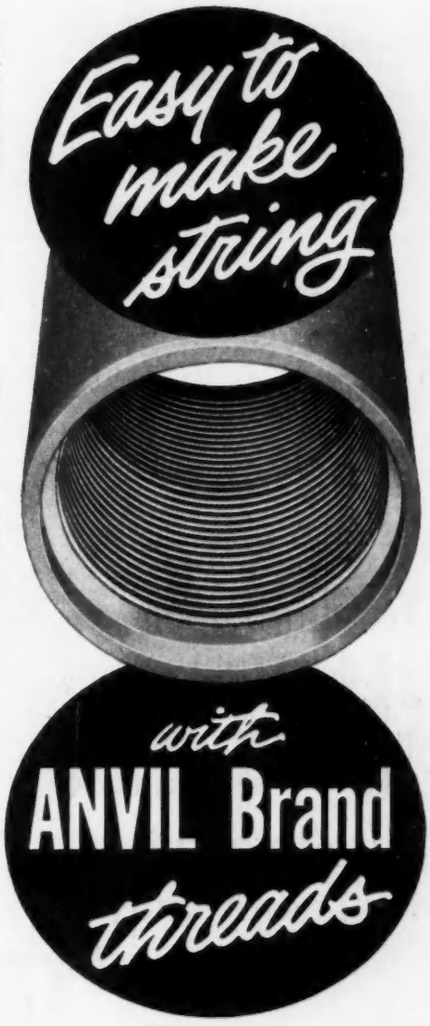

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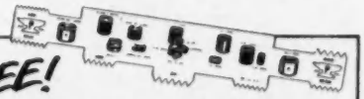
Anvil Brand Fittings—A.P.I. Couplings for all oil field applications, bushings, plugs, and nipples, are sold through your nearest supply store. Engineering service is always available from Anvil Brand Representatives in key oil country locations. Write for information.



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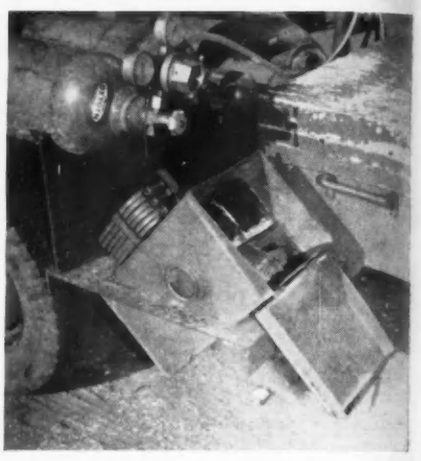
safety and saves time in adding chemical treating agents to the cooling tower water since it is no longer necessary to climb to the top of the cooling tower. Also, more effective chemical distribution is obtained with the proposed method.

(Courtesy Humble Oil & Refining Company.)

Adjust Workover Tongs With Counter Weight

Here is a simple counter weight used to balance the tongs on a workover unit. Run a cable from the tongs through a shoe at the crown block and back down to the (guy) wire anchors. Cut a 50-gallon drum in half and attach it with a bail to the cable as illustrated.

In this case, the drum is filled with scrap iron to provide the weight necessary to balance the tongs. The drum is hung at a convenient place so that more weight can be added if necessary.



Tilt Welding Rod Box For Additional Advantages

Tilting the shop-fabricated welding rod supply box through an angle of about 40 degrees and mounting it on a step slightly below bed level of the field welding truck accomplishes several worthwhile benefits.

Loading or unloading of the heavy rod cartons is facilitated. The rods remain packed in orderly fashion to facilitate easy picking up by the welder; also, they have less tendency to jump around in the carton, with consequent damage to coating, when the truck is going over rough terrain. The storage box, being tilted, takes up less vertical height above and below the step to afford more ground clearance.

The box is designed to hold four cartons of rods and is equipped with a heavy, flanged lid that helps prevent entry of rain and dust.

Simple Chain Hoist Aids Minor Boat Repairs

In an area where large boats or luggers are used, this idea may be put to good use. It consists of a frame made of two pilings and steel H beam with a chain hoist attached as shown in the illustration. A sling is attached to the hoist allowing boat operators to change their shafts, pro-

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A JENSEN JACK is engineered inside and out to lift more oil for less money . . . and that's a fact worth remembering when you install a pump jack.

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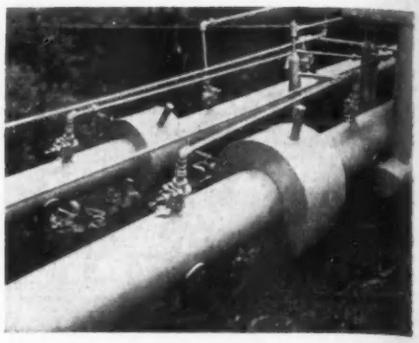
pellers and make other minor repairs.

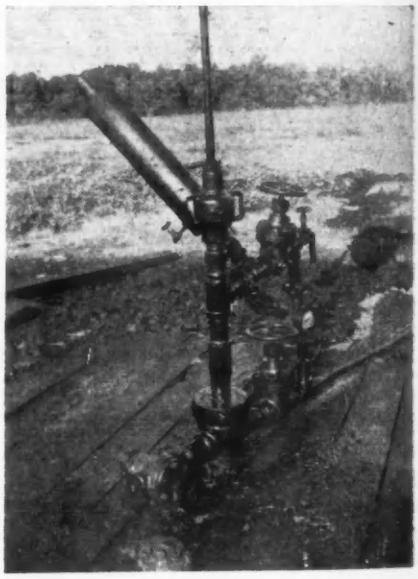
The installation of this simple device has reduced towing time, down time and ship yard repairs for one Gulf Coast operator.

Protect Sheet Metal Hood With Flange Couplings

Anticipating the possibility of corrosion occurring in the vulnerable exposed bolts and surfaces of a flange coupling, particularly in an area frequently subjected to much rain, fog and salt air, one company makes it a practice of not only taping shut the gap between the flange halves, but covering the entire flange with a sheet metal hood. Two such installations are shown in the photograph. The hoods, easily built by a welder out of scrap tank steel or light gage steel sheet, rest upon the flange in saddle-fashion and extend well below the under side of the pipe. A vertical handle at the top of the hood facilitates lifting and handling.



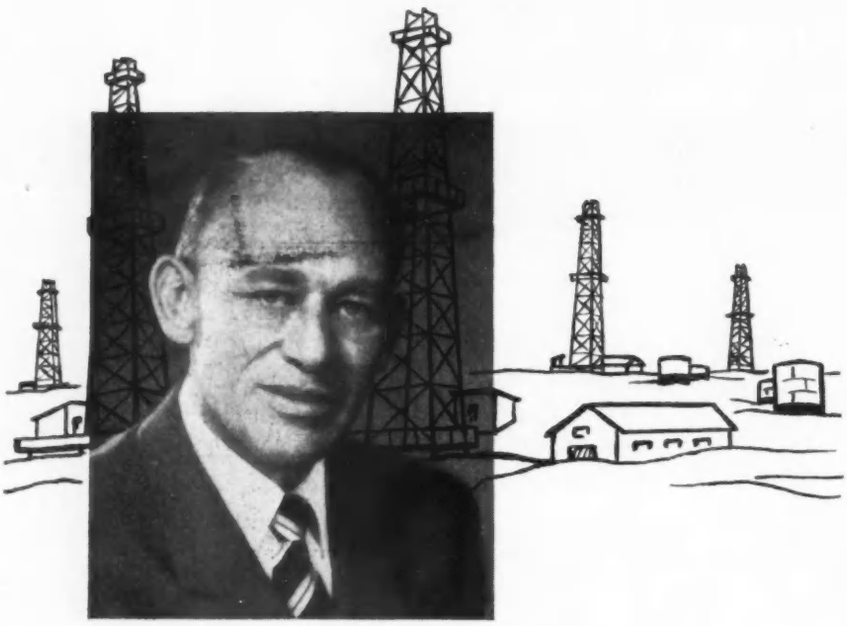
The relatively small cost of such a hood easily can be repaid by the extended corrosion-free life of the coupling.



Hold Paraffin Solvent With Flow Line Pot

Where flow lines are apt to paraffin-up, add a simple pot to the wellhead to make it easy to add the solvent. It consists of a piece of 6-inch pipe with 2-inch connections at each end. Screw a bull plug into the top end and a valve and nipple at the bottom which connects to the flow-line.

At regular intervals, the well may be shut down while the vessel and upper part of the flow-line are filled with paraffin solvent. The pump is



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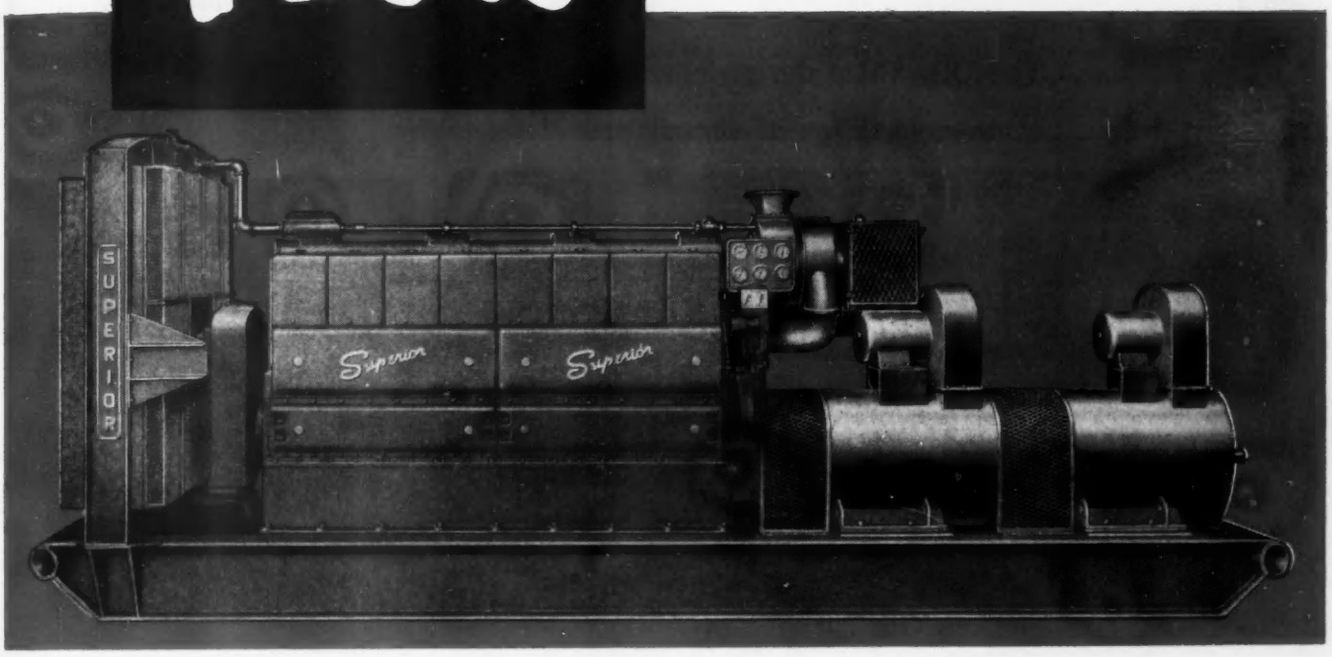

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For complete information and advantages of White's diesel-electric operation, get White's Bulletin 101 available from all leading rig manufacturers, White field representatives, or through the White Diesel Engine Division.

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THE WHITE MOTOR COMPANY
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PRESSURE CONTROL OTIS SERVICE - EQUIPMENT

PRODUCTION HINTS . . .

again started and the slug of solvent is pumped through the flow-line dissolving the paraffin.

If the well is to be shut down over night, the pot may be filled and the solvent allowed to bleed back into the well. This will help to remove a portion of the paraffin which may tend to form in the tubing.

The construction of this solvent pot is illustrated in the photograph and can be varied in size depending upon the amount of solvent required by a particular well.

Buried Exhaust Line Cuts Danger of Fire

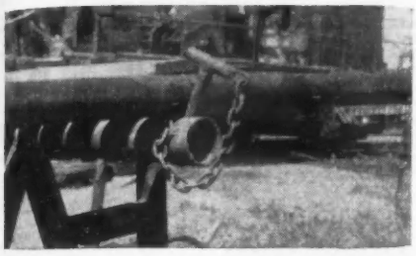
Danger of fire or explosion caused by ignition of accumulated vapors around the well is minimized by the technique employed by one company in extending the pumping engine exhaust line some distance, underground, from the well.

Bring the line up over the engine and down into a shallow trench in the ground. Extend it for some 50 feet out to the edge of the location to terminate in a conventional muffler that is brought up to a few inches above ground level.

Care should be taken, in laying out such an extension, that the pipe diameter will be sufficient to eliminate any chance for back pressure.

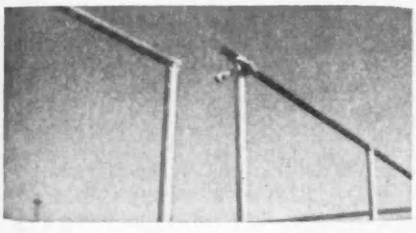
Weld Pipe Rack Chock To Assure Its Location

Nails, rags, boards and just about every conceivable object around the location have been used at one time or another to hold joints of pipe on



the pipe rack. The chock shown in this illustration can't stray very far from where it is needed.

Make it by welding sucker rod material into a "T" shape and connect the "T" to the rack with a short length of chain. Burn a hole in the pipe rack to accommodate the "T" which can be quickly and easily put in place when it is needed. This idea saves time and trouble and possibility of an accident which might result from the use of makeshift chocking device.



Make Gate Easy to Latch With Rod and Steel Plate

The illustrated latch is being used on a long gate made of 1-inch rod. The gate is flexible and can be lifted an inch or two at the open end without much trouble.

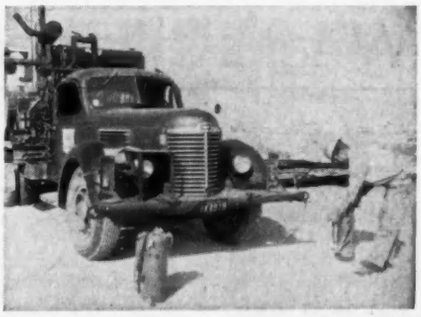
The horizontal rod at the top of the gate is extended three or four inches beyond the end of the gate. With the gate in a closed position this extension lies directly on the rod used at the top of the fence. By making a horizontal saw cut along the middle of the extension and filing a spot on top of the railing, a flat contact can be obtained.

One quarter inch steel plate, cut to fit, is used in making the stops. Weld these close to the top of the gate. This allows them to be lifted over the rail with a minimum of effort whenever the gate is opened or closed.

Fire Fighting Equipment Placed in Ready Position

One major company has a rule that before pulling operations can begin, the fire extinguishers must be removed from the pulling unit and placed on the ground a few feet out in front.

Besides making them easier to reach and placing them in a safer location, the effect of handling the extinguishers just before the operation has a good psychological effect. It makes the men fire conscious, which tends to reduce carelessness. If a fire should occur, there is no question concerning the location of the extinguisher. The roustabout can automatically retrace his steps and have the fire extinguisher in position in a matter of seconds.



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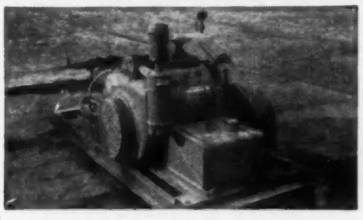
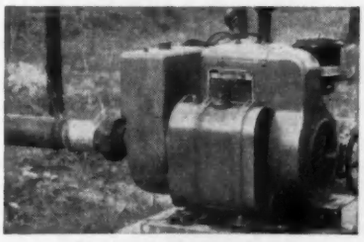


Salt Water Disposal Pump

Trailer-mounted Pumping Unit

Pipeline Dirt Padding Machine



Pipeline Gathering Pump

When water boils away under a scorching summer sun . . . if the temperature should go up to an unbelievable and unbearable 140° F. — or if, on the other hand, it should drop to minimums way below the freezing point during an unseasonal cold spell — *there would be no cause for concern if your equipment is powered by a Wisconsin Heavy-Duty AIR-COOLED Engine!*

Wisconsin Engine AIR-COOLING is entirely automatic and as trouble-free as modern engineering ingenuity can make it. Every Wisconsin Engine from the smallest to the largest is equipped with a large capacity blower, integrally cast as a part of the flywheel. A powerful blast of AIR is continuously distributed over the closely-finned cylinder heads and walls by means of scientifically designed and placed air shrouding, providing correct heat dissipation at all temperatures up to 140° F.

In addition Wisconsin basic High Torque design and heavy-duty construction are assurance of steady-going operating dependability, low-cost maintenance and efficient, economical performance. All models can be equipped with electric starter and generator, or starter only, as original equipment.

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What's Happening

AMONG MEN IN THE INDUSTRY

Harry Jeffries

C. J. Allen

E. L. Steiniger

W. H. Morris

Sinclair Oil Corporation recently promoted five executives to higher posts. **Harry Jeffries** was elected a director and executive vice president—administration, the latter being a newly created position. Formerly, Jeffries was a vice president. As a director he succeeds **A. E. Watts,** who has resigned. **E. L. Steiniger,** a former vice president and already a director of Sinclair Oil Corporation has been elected to the newly-created post of executive vice president—operations. **C. J. Allen,** executive vice president of Sinclair Refining Company, has been elected vice president, Sinclair Oil Corporation, and will serve as administrative assistant to P. C. Spencer, president. **W. H. Morris,** former president of Sinclair Pipe Line Corporation was elected vice president of Sinclair Oil Corporation and will serve as executive assistant to Steiniger in operations. **O. P. Thomas,** former assistant comptroller of Sinclair Oil Corporation has been elected vice president of the same company and will be executive assistant to Jeffries in administration.

O. P. Thomas

•

Edward W. Lang was elected vice president in charge of sales of **Cities Service Oil Co.** (Penn.), principal operating subsidiary of the Cities Service system in the Atlantic Coast area. Lang also was elected a member of the board of directors. Other new board members elected were **Thomas F. McGarey,** vice president and manager of the Asphalt department, and **Henry L. O'Brien,** general counsel of the parent Cities Service Company. As directors, they succeed three retired officers, former president **H. E. Brandli,** former vice president **John D. Morgan,** and former treasurer **Walter W. Martin.**

•

Neal Clayton, former President of **Liberty Exploration Company,** Tulsa, has sold his interest to **J. D. Sides** of Billings, Mont., and the office will be moved to Denver, Colo. Clayton has joined Sohio Petroleum Company at Oklahoma City as staff geophysicist.

•

T. E. Weirich, formerly chief subsurface geologist for **Phillips Petroleum Company's** Land and Geological department, has been named assistant manager of the department's Osage area, Osage County, Okla., and **Renato Passega,** exploration research geologist, has assumed the duties formerly handled by Weirich. Both are headquartered in the Bartlesville, Okla., office. Weirich started with Phillips in 1934 and has been chief subsurface geologist since 1948. Passega started with Phillips in 1948 and became exploration research geologist in July of 1956.

•

William K. Whiteford, president of **Gulf Oil Corporation,** has been elected a director of General Motors Corporation. Whiteford, a Gulf Oil director, is in addition a member of the boards of Jones and Laughlin Steel Corporation and Proctor and Gamble Company.

•

H. D. Fox, Oklahoma district geologist, will be promoted to the newly created position of Oklahoma district exploration superintendent for **Sohio Petroleum Company.** In this position he will report directly to the division exploration manager and will supervise all exploration activities. Also effective **G. W. Velotta,** senior geologist, will be promoted to Oklahoma district geologist. **Bernard A. Taylor,** district geologist at Casper, Wyo., was promoted to Casper district exploration superintendent for Sohio. He started with Sohio in 1946, as a draftsman and later became a geologist, senior geologist and district geologist, all in the Houston district. He moved to Casper as district geologist in 1954. **C. F. Moore, Jr.,** district geophysicist, Billings, Mont., was promoted to Billings district exploration superintendent. He joined Sohio as a seismic observer on a crew in 1946. He worked his way up through the crews to party chief and party manager before going to Casper as a geophysicist in 1952. His appointment as district geophysicist at Billings was effective in June, 1955.

•

Petroleum, Inc., recently announced that **James D. Morris** has joined the company as division geologist for Kansas-Oklahoma. Morris was formerly an independent consulting geologist in Kansas and Oklahoma prior to joining Petroleum, Inc. **Lyman Hill** has been promoted to district geologist for Colorado having been transferred to Denver from Wichita, Kansas, where he served as assistant district geologist for Kansas. Hill was formerly with Sunray Mid-Continent Oil Corporation before joining Petroleum, Inc., in 1955.

Hines H. Baker

Morgan J. Davis

Hines H. Baker, president of **Humble Oil & Refining Company** since 1948, will retire April 29. **Morgan J. Davis,** executive vice president, is expected to succeed him. It is anticipated that Baker will be elected to the board of directors of Standard Oil Company (New Jersey). Baker joined Humble in 1919 as a member of the Law department. In 1940 he was made director in charge of refining and sales. Davis joined Humble in 1925. He has been a director since 1948; was made a vice president in 1951; and executive vice president in 1956.

•

McRae Oil & Gas Corporation of Midland has promoted two executives. They are **Wilbur Rocchio** and **A. N. (Neil) Brown.** Rocchio now is executive vice president of McRae Oil & Gas and president of its wholly-owned subsidiary, Roden & McRae Drilling Corporation. Previously he had been vice president of both concerns. The position of executive vice president of the drilling corporation is a new one. Rocchio succeeds McRae, who moved up to chairman of the board. Brown, manager of the Land department of McRae Oil & Gas, has been elected a vice president of the concern. He will continue in charge of the Land department.

•

Trunkline Gas Company announced the appointment of **Raymond E. Fairchild** as Houston district geologist. Fairchild comes to Trunkline Gas from Pan American Production Company, where he was district geologist in the Houston office until the firm merged with Stanolind Oil & Gas Co. More recently he served as a geological consultant to Pan American. As a district geologist for Trunkline Gas, Fairchild will be in charge of the company's geological activities in the Houston area of the Texas Gulf Coast. He joined Pan American Production Company in 1950 after completing his education.

Raymond E. Fairchild

•

Tony Gibbon, eastern division geological representative for **The Carter Oil Co.,** is

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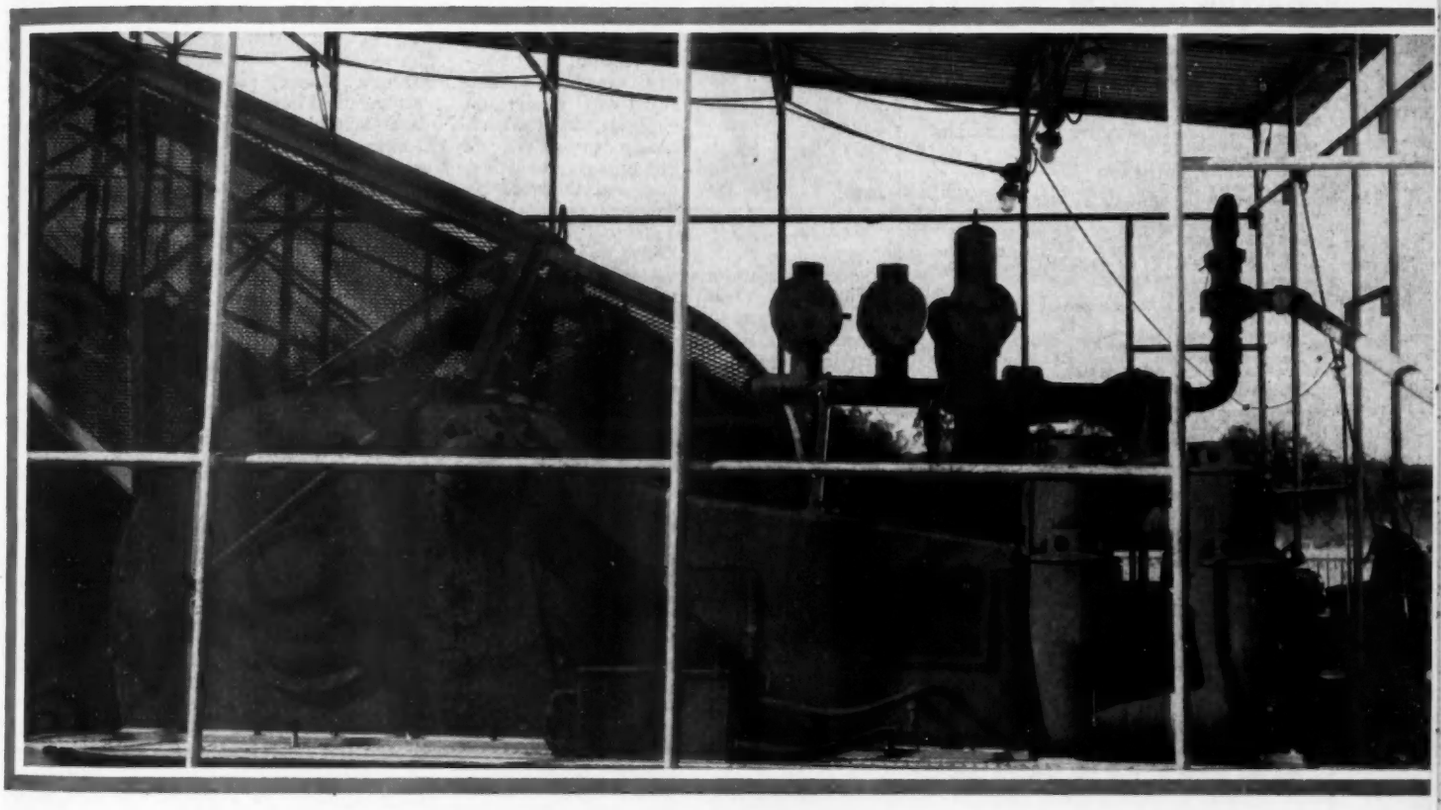
are an important part of the drilling team!



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being transferred to Durango, Colo., where he will be area geologist. Replacing Gibbon in Tulsa is **R. E. Johnson.** The Durango office is Carter's headquarters for the Four Corners area.

•

Hugh B. Hodges, retired drilling contractor and independent oil producer, has been elected to the **Sunray Mid-Continent Oil Company's** board of directors.

•

Moody Covey has been promoted to safety supervisor of **Tidewater Oil Company's** Seven State and Hawaii Western division. Covey will be responsible for supervising accident control programs, guidance in eliminating unsafe practices and conditions, recommending protective equipment and accident prevention methods, and participation in accident prevention investigations and analyses. He will make his headquarters here. Covey joined Tidewater in 1950 as a junior engineer at its former Drumright, Okla., refinery. Previous to his present appointment, he was divisional safety supervisor for the company's Southern division with headquarters in Houston.

Moody Covey

•

R. A. Appleman has been named general traffic manager of **Esso Standard Oil Company,** in New York City. Appleman has been with Esso Standard since 1919 and had been assistant general traffic manager since March, 1955.

•

Michael Singer, president of **Federal Oil Company,** has been elected a trustee of St. James Hospital in Newark, N. J.

•

Russell D. Richardson has been elected treasurer of **Tidewater Oil Company** in addition to his present responsibilities as controller. Richardson started with the company 36 years ago as an accounting clerk at the Avon Flying A Refinery near San Francisco. He became chief accounting clerk in 1927, advancing to the post of assistant regional controller of Tidewater's Western division in 1936. He served as regional controller from 1939 to 1954, and in the latter year was named controller for the entire company.

Russell D. Richardson

•

The Geotechnical Corporation, Dallas announced the election of **F. H. Kennedy** as a director and **J. Lee Wood** as a director and vice president of the company. Kennedy joined Geotechnical in 1936 and is vice president in charge of manufacturing. Wood joined Geotechnical in 1954, and was formerly chief contracting officer of the Dallas Air Procurement district of the Air Force.

Cosden Petroleum Corporation has elected **Ernest K. Dodson** a vice president. The action was announced by **R. L. Tollett,** president, who stated that recent growth of the corporation in the acquisition of Col-Tex Refining Company and of the Hawley refinery of Onyx, and in the expanding of crude producing facilities, has made necessary the designation of an administrative vice president. These duties will be handled by Dodson. The newly designated vice president has previously been in charge of Cosden's Midland, Texas, Land office, and has temporarily assumed the duties of **Marvin M. Miller,** vice president in charge of the Producing division, during Miller's absence while enrolled in the Advanced Management School of Harvard School of Business Administration. Dodson joined Lion Oil Company in 1937 as an accountant, and has spent the last 20 years either in the oil industry, or in the practice of public accounting closely related to the industry.

E. K. Dodson

•

Sidney A. Swensrud will retire as chairman of the board from **Gulf Oil Company** April 23. There will be no successor due to an executive rearrangement. Swensrud joined Standard Oil Company of Ohio in 1928 and eventually became executive vice president. He joined Gulf in 1947 in the same capacity. In 1948 he was made president and in 1953 chairman of the board.

•

Seaboard Oil Company announced the election of **Harvey Cash,** assistant to the chairman of the board of The Texas Company, to the board of directors of Seaboard, replacing **R. F. Baker** who resigned upon his retirement from Texaco last January.

•

Richard W. Scott, who has been manager of exploration for Warren Petroleum Corporation's Oil division with headquarters in Houston has resigned. Scott will move to Buena Vista, Colo., where he will engage in business for himself.

•

Alex W. McCoy Associates, Inc., Tulsa, named an additional vice president and a chief geologist and approved plans to expand regional offices. **Wayne E. Swearingen,** chief engineer for the petroleum engineering and geological consultant firm was elected vice president for engineering. **Dr. Carl Moritz,** executive vice president, was appointed chief geologist to coordinate the independent firm's geological consultant work.

•

M. J. Rathbone, president of **Standard Oil Company (New Jersey)** has been given the Stevens Institute of Technology (Hoboken, N. J.) award for notable industry achievement, in recognition of his work in "an industry so intimately involved with the industrial economy of our nation and in its military defense." The ceremony took place in the Sheraton-Aster Hotel in New York City February 2.

A performance report from
The La Gloria Corporation
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satisfactory"

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The HMAB-10, installed at Waskom, Texas, is a completely self-contained packaged compressor station developing 550 bhp. The La Gloria Corporation is using it to gather gas at 50 psig. and compress it in two stages to 980 psig. Subsequent to after-cooling, the gas is piped to a gasoline plant where it is stripped and sold to a pipeline company.

Similar in appearance to the smaller HMA, the new unit incorporates the basic design features of the HMA as well as many new innovations. Foremost of these is a new radiator and hydraulic radiator drive. Both the radiator and drive have completely measured up to expectations with flawless operation.

Substantial savings in erection time were realized at Waskom because the HMAB-10 was delivered as a factory tested, completely assembled unit. Balanced/Opposed design greatly reduced foundation needs.

One very important consideration for users of this 550 bhp. unit is the fact that it is equipped with five compressor cylinders as standard equipment. If field pressures drop excessively, conversion to three-stage operation is easily accomplished. There is also ample physical space in the radiator to add another cooling section for additional intercooling. Demand for this new unit is heavy but new production facilities will soon be ready to speed deliveries. Be sure to get all the facts on the HMAB from your nearest Clark representative.

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J. E. Vaeth, veteran Fort Worth, Texas, oil man and executive vice president and a director of Southern Production Company, Inc., until the acquisition of its oil and gas properties by Sinclair Oil & Gas Company, has resigned from an executive position with Sinclair to become an independent oil operator in Fort Worth. Vaeth has spent practically his entire adult life in the oil business. He went to work for Danciger Oil & Refining Company in 1920 in Wichita Falls, Texas, moved to Fort Worth in 1927 to set up the Danciger general offices and was named a vice president of Southern Production when the two companies merged in 1950. Vaeth later was promoted to executive vice president and was elected a director in 1951. He was also a director of The Offshore Company, Southern Production subsidiary. When Sinclair purchased the oil and gas properties of Southern Production last November 1, Vaeth joined Sinclair in an executive capacity in Fort Worth.

J. E. Vaeth

•

Dr. William P. McKinnell, Jr., has joined the staff of the Engineering section of **The Ohio Oil Company's** Research Center in Denver. McKinnell was employed at Chrysler Corporation, Highland Park, Mich., and as an assistant professor of metallurgy at Virginia Polytechnic Institute previously.

Walter F. Rogers, chief chemist of the Houston Production division Chemical unit of **Gulf Oil Corporation,** received the Frank Newman Speller Award, presented by the National Association of Corrosion Engineers in St. Louis, March 13. Rogers, who is founding father of the organization, is the tenth man to receive the Speller Award, established in 1947 and named in honor of the first recipient. It is given annually to scientists who have made significant contributions to the world's knowledge of corrosion control. He first came to the company in Port Arthur, Texas, in 1926 as a chemical engineer at the refinery. In 1927, he came to Houston to work for the Gulf Production Company under a fellowship from the Mellon Institute, primarily concerned with oil well corrosion problems. In 1949, he was made chief chemist, the position he now holds. In this capacity, he is in charge of four units: core analysis, reservoir fluid, production and drilling. Rogers is the author of the book "Composition and Properties of Oil Well Drilling Fluids," also many technical articles on corrosion of producing and pipe line equipment. He was president of NACE in 1953 and has also served on numerous other committees.

Walter F. Rogers

•

James Wesley Yarbro

James Wesley Yarbro has joined **Texas Pacific Coal and Oil Company** as comptroller. Yarbro has been assistant secretary-treasurer and tax manager of Southern Production Company for the past six years. Prior to that he was with the Bureau of Internal Revenue for five years.

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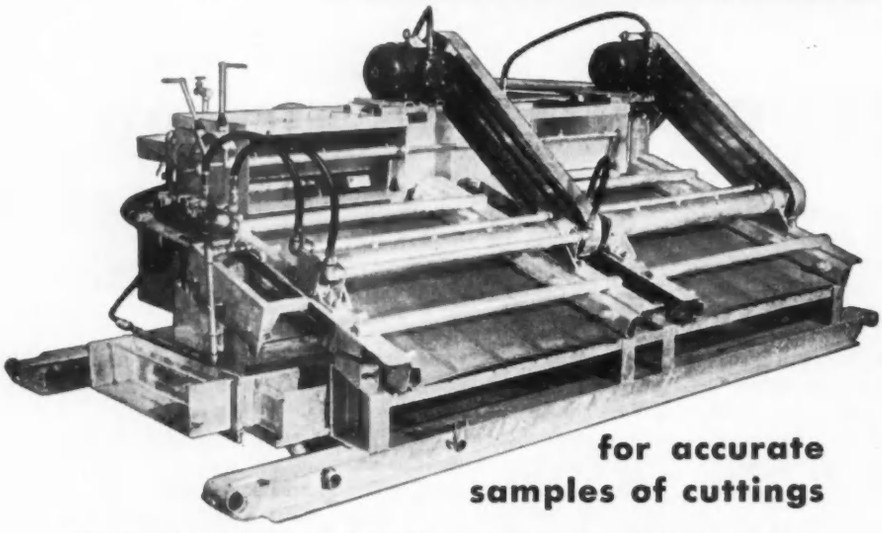
DOUBLE VIBRATING SHALE SHAKER...and SAMPLE MACHINE



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A. D. Dunlap, associated for 23 years with **Independent Exploration Company,** was recently made director of operations for IX. Before his promotion he was the manager of Independent Exploration's Canadian branch. Dunlap, as director of operations, is responsible for the efficient activities of all the domestic field crews. He also helps coordinate crew findings with requirements of the Laboratory and Interpretation department.

A. D. Dunlap

Warren Petroleum Company made several organizational and personnel changes in the Manufacturing division. The organizational changes include the formation of three operating areas, each in charge of a superintendent of operations, and an increase from three to six in the number of operating districts. Each of the six districts will be in the charge of a district superintendent. At the same time **C. W. Miller** was advanced from assistant manager to manager of the Manufacturing division, and **W. S. McAllister,** formerly district superintendent at Gladewater, Texas, was transferred to Tulsa as chief engineer of the Engineering department. **L. M. Mauney** has been named superintendent of operations for the Northern area composed of Districts 1 and 2; **C. C. McKee,** superintendent for the Southern area which includes Districts 3, 4 and 5, and **E. C. Lindenberg,** superintendent of operations for District 6, composed of The Garvin County plants. District No. 1 will be managed by **E. K. Sloan** of Wichita Falls, Texas, who will have the Holliday, Madden, McLean and Breckenridge plants under his supervision. District No. 2 will be managed by **F. E. Thompson** of Tulsa with the Maud, Madill, Crossville, Ringwood and Marlow plants under his supervision. District No. 3 will be managed by **T. E. Raper** of Hobbs, N. M., and will be comprised of the Monument, Saunders, Townseld-Eidson booster and Dean-Caudill booster plants. District No. 4 will be in the charge of **Sam B. Summers** of Houston. It includes plants at Fairbanks, Mont Belvieu and Conroe. District No. 5, managed by **E. V. Hodge** of Gladewater, Texas, includes the plants at Hawkins, Gladewater, Gregg-Tex and East Texas pipe line. District No. 6 will be managed by **Guy Barritt** of Maysville, Okla., with the Maysville, Lindsay, Antioch, Panther Creek and Eola station plants being under his supervision. Other personnel changes include the transfer of **Marvin Hindman** from the superintendency of the McLean plant to the superintendency of the Midland Gasoline Corporation plant at Conroe, Texas. He was succeeded at McLean by **M. M. Burroughs,** formerly district clerk for The Garvin County Plants at Maysville. **J. W. Kearney** has been transferred from Hobbs, N. M., to the superintendency of the Hawkins, Texas, plant. **H. A. Yates,** formerly plant foreman at the Marlow plant, has been named superintendent of the Maysville plant.

•

Frank Richardson has been appointed manager of the Production and Exploration department of **Lion Oil Company,** a division of Monsanto Chemical Company. Richardson has been assistant to **J. E. Howell,** Lion vice president in charge of production and exploration. **Robert I. Williams,** formerly manager of the company's Rocky Mountain region, has been named assistant manager of the department and will transfer from Denver to El Dorado, Ark. **Eugene L. Maxwell** replaces Williams as manager of the Rocky Mountain region. Maxwell, who has been manager of the Central region with offices in Wichita, Kansas, will be stationed in Denver. Replacing him in Wichita is **Robert P. Evans** who has been assistant manager of the Southwestern region with headquarters in Midland, Texas. Richardson joined Lion in 1936. Williams has been with Lion since 1938. Maxwell was first employed by the company in 1946. Evans also joined Lion in 1946.

•

C. D. Owens, Jr., industrial relations assistant for **Sinclair Oil & Gas Company,** has been promoted to manager of industrial relations for the company. Owens joined Sinclair in 1949.

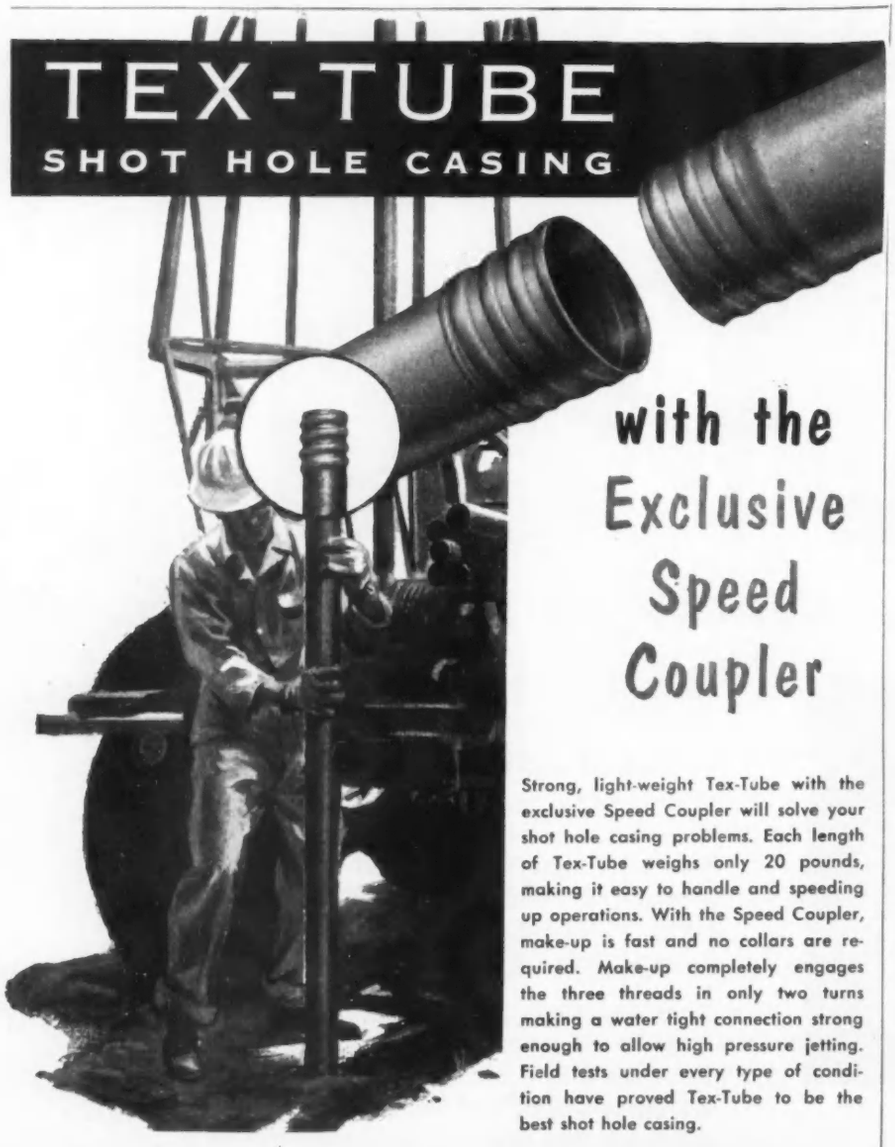
•

Cosden Petroleum Corporation has announced the appointment of **Garth W. Reed** as division sales manager in northwest Texas. Before joining Cosden, Reed spent 37 years with Panhandle Refining Co., with whom he was vice president in charge of sales.

•

William J. Sherry of Tulsa, independent oil producer, has been given a merit award by the Massachusetts Institute of Tech-

TEX-TUBE
SHOT HOLE CASING



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	(Gulf Coast Explosive Co.)	CEnter 4-3876
Brookhaven, Miss.	(Bilderback Dynamite Co.)	2732
Mills, Wyo.	(Teton Tool Co.)	CAsper 2-8181
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nology for his outstanding work in promoting the engineering profession. Sherry is an MIT alumnus and an official of the Oklahoma MIT Alumni Society.

•

Eugene Holman, chairman of **Standard Oil Company (New Jersey)** has been elected a director of the Metropolitan Life Insurance Company in New York. Holman retains his post as chairman and chief executive officer of Jersey Standard.

•

J. L. Wait has been appointed coordinator of marketing trade relations for **Continental Oil Company.** Formerly administrator of special assignments for Conoco's Marketing department, he will continue to make his headquarters at Houston and will assume the duties formerly handled by **O. B. Lloyd,** who retired in January. Wait joined Conoco in 1917 at Albuquerque, N. M., and became assistant division manager at that location in 1929. He transferred to Chicago in 1934, where he served successively as assistant division manager, division manager and northern marketing manager. Since 1952, he has held several key positions in the company's Marketing departments in Spokane, Wash., New Orleans and Houston.

•

Standard Oil Company (Indiana) announced the appointment of **Edwin J. Farrel** and **Warren G. Moeller** as employe relations supervisors in the Research department of the company at Whiting, Ind. Farrell has been with the company since 1947 when he was employed as an automotive engineer. Moeller was employed by Standard Oil in 1947 as a chemist.

•

Frank B. Fulenwider has been appointed marketing manager for Central division of **Tidewater Oil Company** with headquarters at Tulsa. He will succeed **John W. Warner,** whose request for retirement, effective January 31, was granted. Fulenwider in 1955 was transferred from the company's Western division to the Central division at Tulsa as assistant marketing manager. During his 22 years with Tidewater Fulenwider has held various positions in the company's Marketing department, particularly on the West Coast.

Frank B. Fulenwider

DEATHS

Walter L. Goldston, 62, died in a Houston hospital January 22. The independent oil producer entered the oil business in 1916 as a geologist. He had been associated with Empire Gas and Fuel Co., The Texas Unity Oil Co., and was chief geologist and vice president of the Cranfill-Reynolds Co. before becoming independent. During his career Goldston discovered oil in six major fields in three states as well as in lesser areas.

Walton G. (Walter) Christian, 76, retired drilling contractor and independent producer, died January 6 in Houston.

Charles B. Peters, 79, chairman of the Norbla Oil Company, Tulsa, died January 18.

I. R. (Ike) Minton, 47, vice president of the Fleet Drilling Co., Ada, Okla., died January 7, in Oklahoma City at a meeting of the Oklahoma Independent Oil Association convention. He joined Fleet in 1948 and was in charge of the company's public relations.

Clarence A. Wiggins, 62, who retired as president of the Drilling and Exploration Co., Inc., January 1, died January 7 in Houston.

William Henry Brimm, 77, independent oil operator, died January 4, in Tulsa. Brimm helped develop several fields in Oklahoma, Texas, Louisiana and Kansas.

Clyde B. Thompson, 32, geology trainee with Sohio Petroleum Company died January 25 in a plane crash near Bryan, Texas.

Donald Crary, superintendent of exploration for Sohio Petroleum Company, died January 25 in a plane crash near Bryan, Texas.

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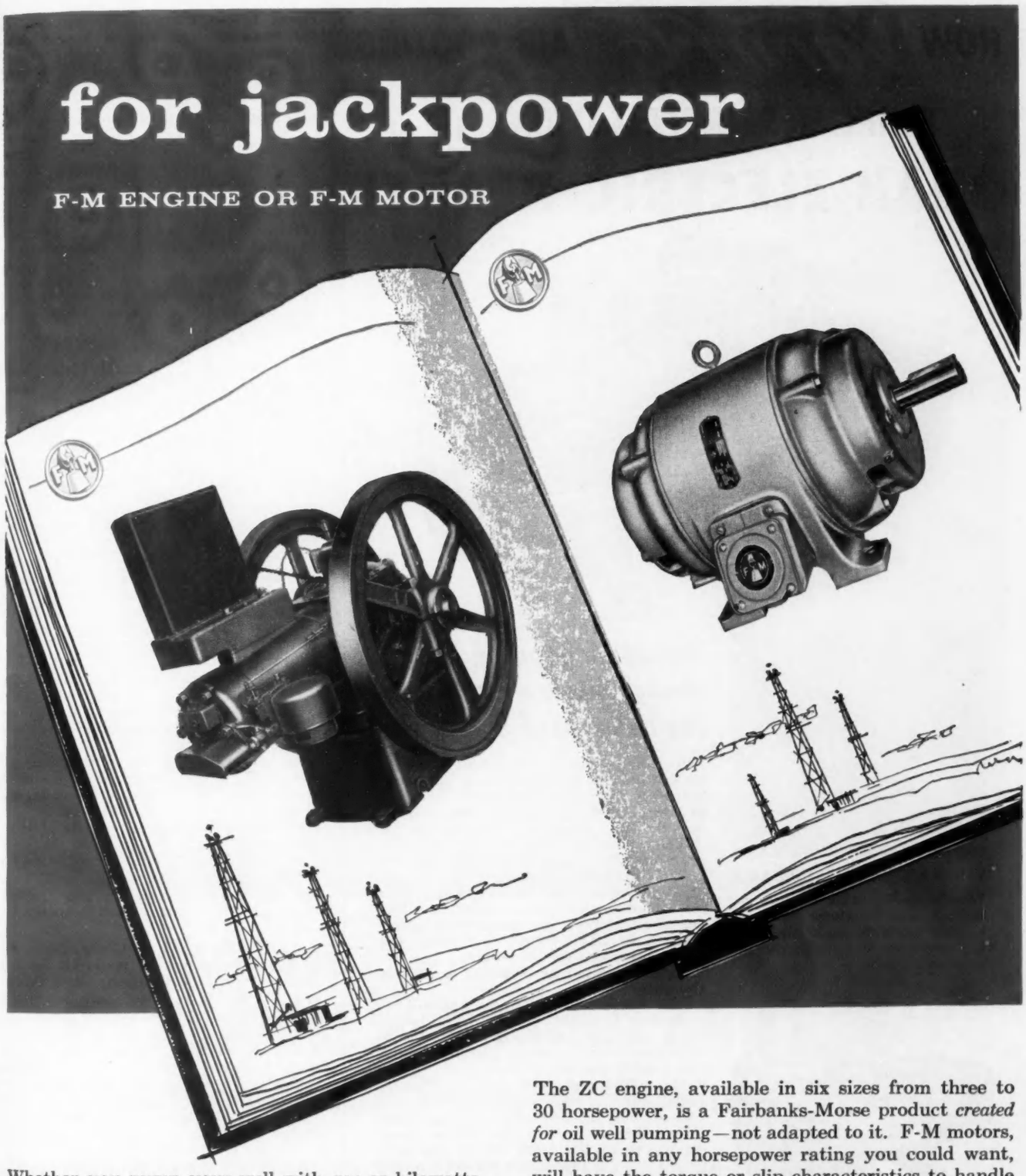

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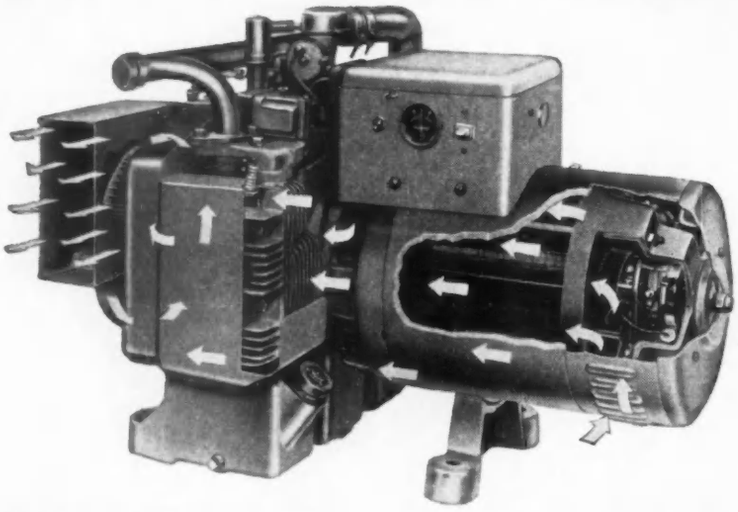

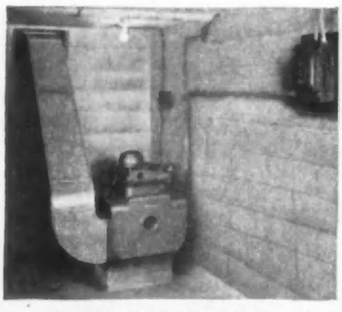

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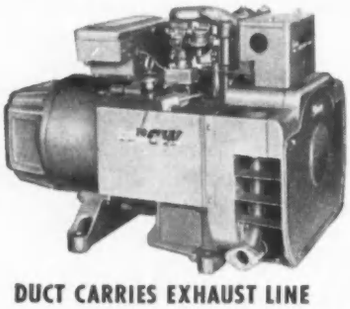
Vacu-Flo cooling takes air from the room, through the electric plant, and expels it outside through a single duct. Eliminates fumes; keeps room filled with fresh air.



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Air-cooled Onan Electric Plants can now be installed in small, enclosed compartments; in isolated or underground rooms; or "buried" within a vehicle, far from the outside air. Previously impossible or difficult installations are now easy and practical with Onan Vacu-Flo cooling.

This exclusive system is a factory-equipped item, optional on any Onan air-cooled electric plant. A quiet-running, centrifugal blower in a specially-designed housing PULLS cooling air through the generator and over the engine . . . then EXPELS heated air through a duct to the outside.

The space required in a "buried" installation need be only a little larger than what the unit itself requires. Air-intake and vent openings plus an exhaust line are all that are necessary.

On vehicles such as trailers, display vans, fire and rescue trucks, and concession wagons, Vacu-Flo cooling makes it possible to mount the Onan plant anywhere in the body where space is available. On pleasure and work boats, Vacu-Flo cooling makes below-deck installations of air-cooled electric plants practical . . . cooling efficiently and quickly eliminating fumes from the area.

Onan Electric Plants with Vacu-Flo cooling operate more quietly than blower-cooled models . . . an important added advantage in many installations.

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Foster Brooks Parriott, 78, chairman of the executive committee of Sunray Mid-Continent Oil Corporation, died February 5. He entered the oil business in 1900 and was associated with M. L. (Mike) Benedum of Pittsburgh, Penn. He moved to the Southwest in the early part of the century and opened a number of important oil fields. He was president of Transcontinental Oil Corporation, until its merger with The Ohio Oil Co. He helped organize the Plymouth Oil Company. He was named a director of Sunray Oil Corporation in 1937 and became board chairman in 1943, serving in that capacity during a period when Sunray acquired through merger a number of strong independent oil companies. He was named chairman of the executive committee in 1952.

Harry E. Disler, 72, former field superintendent, for The Carter Oil Co., Tulsa, died January 21 in Long Beach, Calif.

Wendell G. Thayer, 52, former executive director of the Pacific Oil Institute, died January 5 in an Orange, Calif., hospital. He was a former employee of the Conservation Committee of California Oil Producers and was with Union Oil Company for several years.

William Burton Moss, 62, retired drilling contractor, died January 6 in a Tulsa hospital. He had been active in northeast Oklahoma for many years before retiring in 1942.

Edward A. Skinner, 64, oil pioneer of the Persian Gulf and vice president of the Bahrain Petroleum Company, Ltd., an affiliate of the Caltex group, died recently in a New York City hotel. Under Skinner's supervision, a major oil discovery was made in 1932 on Bahrain Island in the Persian Gulf. For many years he was closely associated with developing the vast oil resources of that part of the Middle East.

William K. Ward, 55, formerly with Warren Petroleum Corporation and the old Devonian Oil Company, died February 12.

Sidney L. Boyer, 61, of Grove, Okla., retired superintendent of materials for the Service Pipe Line Company, died February 12. He had retired last September after 33 years with the Service firm.

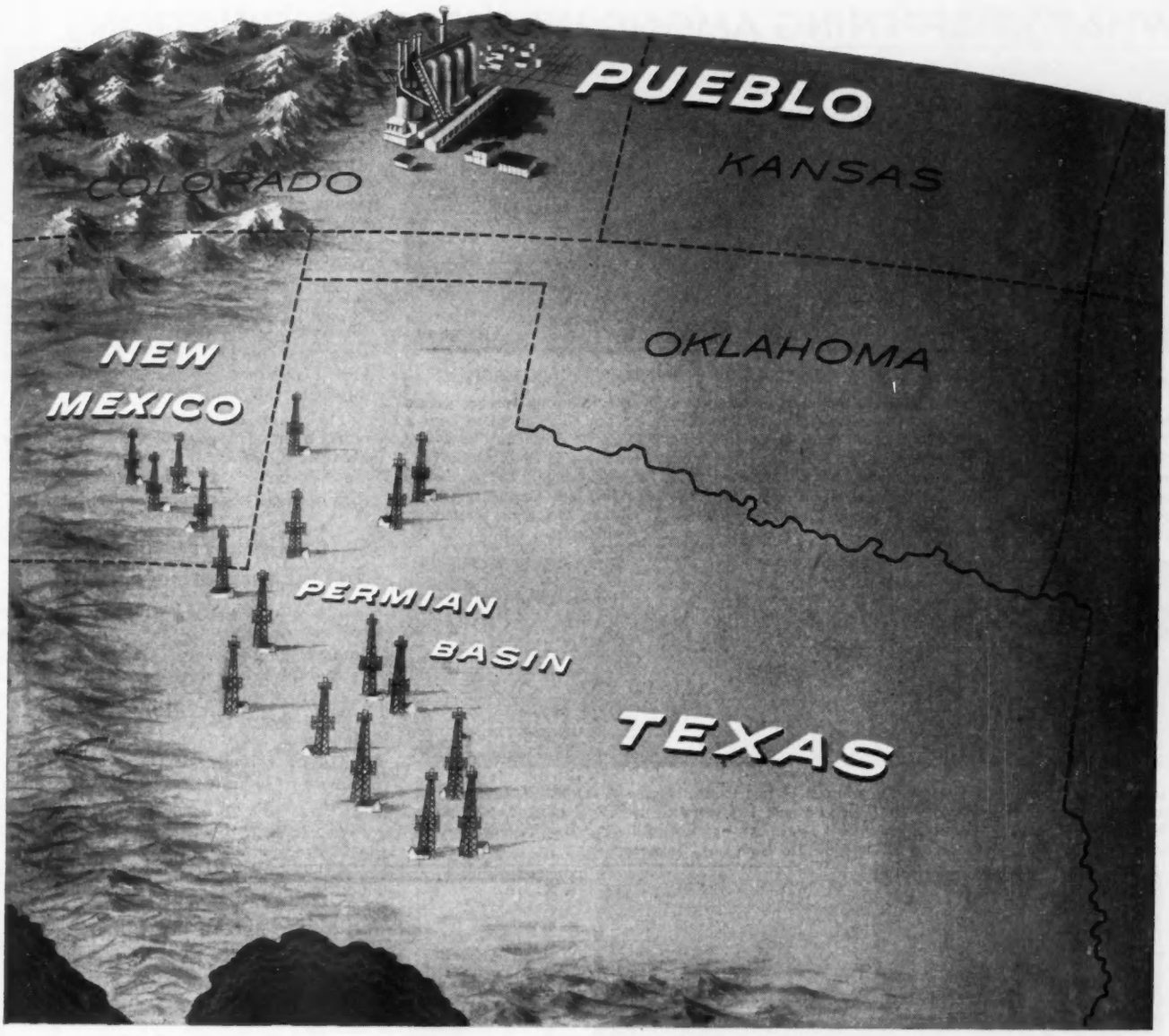
Arthur K. Bosanko, 57, sales executive in the Products department of Marketing Coordination division of Standard-Vacuum Oil Company, died December 9 at Glens Falls, N. Y. He was a veteran of 25 years service in India.

Richard M. (Dick) Tuttle, 59, founder and president of the Pact Gas Co. of Cushing, Okla., died February 8 at his home.

Warren W. Baker, 65, Marshall, Ill., retired vice president of the Pipe Line department of Sinclair Refining Company, died February 9 in a Paris, Ill., hospital.

E. J. Griffin, 48, sales assistant to the vice president of Shell Oil Company's West Coast Marketing division, died February 1 in a San Rafael, Calif., hospital.

C. Ray Gilliland, 65, oil promotor of Scottsdale, Ariz., died January 30.



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WHAT'S HAPPENING AMONG INDUSTRY ASSOCIATIONS

Nomads Have Foreign Guests

The Houston chapter of Nomads were honored last February by the following foreign guests. They are, front row, left to right: Messrs. Miguel Tejada, YPFB, La Paz, Bolivia; Rene Najera, YPFB, La Paz; Delbert D. Lewis, Import Tool Company, Calgary, Alberta, Canada. Back row, left to right: Jack Parks, Mene Grande, Eastern Venezuela; John Newkirk and R. E. McCafferty, Amerada Petroleum Company, Hargeisa, British Somaliland; F. George Bestall, British Consul, Houston; and Fernando Halpern, formerly from Argentina, now with the Fish Engineering Company of Houston. The speaker of the evening was Warren L. Baker, editorial director of WORLD OIL.

Visitors at the March meeting of the Houston Nomads were: Steve R. Pounds, Trinidad Oilfield Service, Trinidad, British West Indies; Martin Mears, superintendent, STA, Turkey; Martin Newell, Tidewater Oil Company, Los Angeles; Virgil Lee, Houston; R. L. (Red) Foster, Socony Mobil Oil Company, New York, and J. C. Robbins, Iran Oil Company, Teheran.

Oklahoma's Governor Gary Elected IOCC Chairman

Gov. Raymond Gary of Oklahoma was elected chairman of the Interstate Oil Compact Commission for 1957, during the closing sessions of the Commission's annual meeting in Miami Beach, Fla., recently. He succeeds Gov. John F. Simms of New Mexico.

Clarence T. Smith, Illinois representative, was named first vice chairman, and John Paul Jones, Pennsylvania representative, was named second vice chairman. Earl Foster was re-elected executive secretary.

The states of Arkansas, Colorado, Illinois, Kansas, Louisiana, Montana, New Mexico, Oklahoma, Pennsylvania, Texas and Wyoming will compose the membership of the Executive committee for 1957.

OIIC Shortens Initials To OIC for Simplification

The Oil Industry Information Committee has shortened its name, effective last January 1. Henceforth, it will be known as the Oil Information Committee, and its initials will be OIC instead of OIIC, according to M. S. Hauser, 1957 national chairman.

Hauser said the decision to change the name was approved at a recent meeting of the National Committee, and that it was based on a general feeling of the membership that the simpler name was

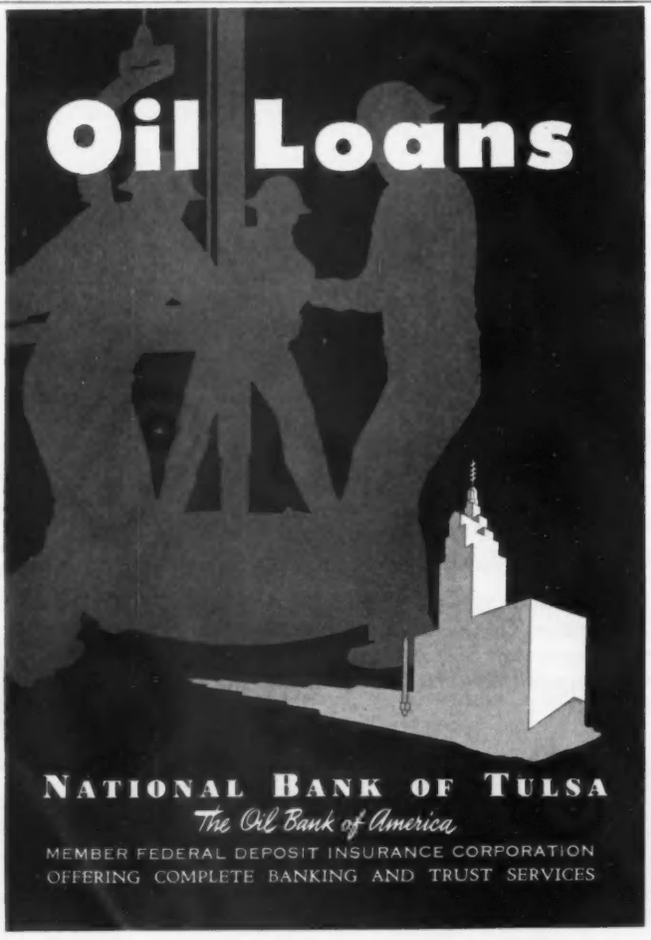
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Diagram and cutaway view of COSASCO Access Nipple with plug installed. (Formerly the Scotch Nipple).

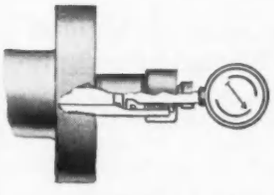
Wherever COSASCO Access Nipples are installed, you can go in against pressure with ease and perfect safety. At well heads, either the production string or annulus can be entered for instrument work. At refineries or along pipe lines, samplers, thermocouples, hydrogen probes, or coupons for corrosion studies can be inserted *without interfering with operations!* And expensive valves or other externals can be replaced or removed at will and without loss of pressure or product.

The COSASCO Access Nipple has a removable low carbon grade 303-304 stainless steel plug which, when turned down on the fine threads in the nipple outlet, effectively seals off the nipple at a tapered seat below. By-pass holes in the plug wall, between primary and secondary seals, provide communication through the plug to the exterior when the plug is backed out against a safety ring run down on the pipe threads on the nipple body.

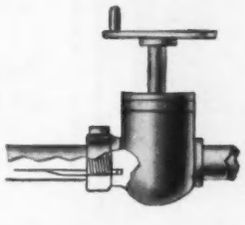
How entry is gained

With the COSASCO Retriever (Lubricator) and a full-opening valve mounted on the Access Nipple, COSASCO plugs, coupon holders or other units for inspection, testing, sampling, can be installed and removed at will regardless of pressure and without equipment shutdown. Details will be supplied promptly, on request.

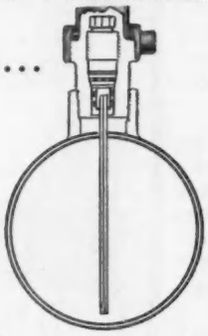
How **COSASCO** *Access* Nipples are used...



As a gauge valve, with plug installed. Gauge screws into end of plug.



As a valve re-installation nipple, with a thread and seat protector replacing the plug.



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The PACIFIC steel ball valve cage, with a flexible, resilient ball valve guide bonded to the cage, *costs no more* than a standard steel ball valve cage, *yet it will give three to four times the service.*

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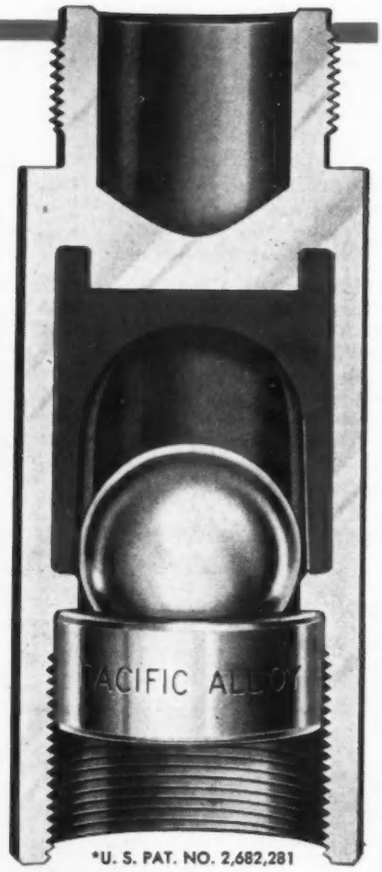

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preferable. The Oil Information Committee designation has been in effect on the West Coast for several years.

IPAA Promotes Lambert; Sherrod Joins Association

Two personnel changes have been announced by the Independent Petroleum Association of America, national oil and gas producers' trade organization with headquarters in Tulsa. Richard D. Lambert of Tulsa, who has been associate editor of IPAA's magazine, the Independent Petroleum Monthly, was transferred to Washington as assistant director of information, and Gene R. Sherrod of Houston has joined IPAA as district representative.

Lambert, who has been with IPAA since Feb., 1956, will serve in a public information capacity in Washington, and also will continue to contribute to the Association's magazine. He had worked with the Tulsa Tribune, the Tulsa World and the Dallas Times-Herald before joining IPAA, and also had been Oklahoma correspondent for the magazine Business Week.

Sherrod will be headquartered in Houston as IPAA's new district representative for northeast, southeast and southwest Texas, and all of Louisiana and Mississippi. He was division title supervisor in Houston for Sinclair Oil & Gas Company before joining IPAA. Previously he had been with the Bell Telephone System.

Texas Desk, Derrick Club Visit Oil Fields, Refinery

Desk and Derrick Club girls of the Lower Rio Grande Valley of Texas sought their petroleum information first hand. At two recent meetings in McAllen, lecturers made speeches on oil drilling mud.

They have also taken chartered bus trips to oil fields in Starr and Hidalgo counties, to the Petroleos Mexicanos operations in Reynosa, Mexico, across the Rio Grande from McAllen, and to Bishop, Texas, to visit a celanese plant.

At least half of the Oil Progress Week observance in McAllen each year is handled by the Desk and Derrick Club in connection with the Chamber of Commerce Petroleum committee.

Delano Succeeds Maland As NY Nomad President

The New York Chapter of Nomads recently elected Maurice F. Delano, Jr., to serve as president for the year 1957. He is replacing retiring president Herb Maland.

Other officers are E. E. Andreason, vice president; Hollis W. Haltom, treasurer; John E. George, assistant treasurer; Don E. Kircher, secretary; Harold E. Lowrey, assistant secretary; W. E. Volkman, sergeant-at-arms; John D. Evans, Jr., and Bernard J. Foy, assistant sergeants-at-arms; Stewart D. Beckley, senior regent; and Herb E. Maland, junior regent.

OIPA Elects Schultz President; Dunlap Veep

Paul R. Schultz, Jr., president of Blackwell Oil and Gas Co., Tulsa, has been elected president of the Oklahoma Independent Petroleum Association. Other officers: Erritt Dunlap, Ardmore, vice pres-

ident; Carl Anderson, Oklahoma City, secretary-treasurer. Schultz succeeds Roy G. Woods of Oklahoma City.

Harold N. Hickey

Porter Montgomery

Hickey, Montgomery Head Gulf Coast Geologists

Recently, the Gulf Coast Association of Geological Societies elected Harold N. Hickey, New Orleans, as president and Porter Montgomery, San Antonio, Texas, as vice president. Hickey succeeds Robert L. Layden of San Antonio and Montgomery succeeds Michael W. Beckman of Shreveport, La.

Other officers are W. K. McWilliams, New Orleans representative; Charles W. Holcomb, Corpus Christi representative; S. N. Warburton, south Louisiana representative; A. E. Blanton, Jackson, Miss., representative; Jules Braunstein, editor, and E. A. Gibson, New Orleans, alternate.

The annual meeting will be held November 6-8 in New Orleans with headquarters in the Roosevelt Hotel.

Kelley Is New President Of LA Petroleum Club

At the annual meeting of the board of directors of the Petroleum Club of Los Angeles, last January, J. C. Kelley, partner in the firm of Hillman-Kelley, was elected president. He succeeded Olen Lane, vice president of Continental Oil Company in charge of west coast operations.

The Club, which has its quarters in the Statler Hotel, has approximately 1000 members representing all phases of the petroleum industry. It was organized in 1948 by a group of members of the Oil Club.

Other officers elected were: vice president, T. H. Wallace, Western Gulf Oil Company; treasurer, Gordon D. Campbell, General Petroleum Corporation; secretary, R. Sneddon, manager of the club.

Independent Producers Pick Davenport General Counsel

A. E. Herrmann, president of the Texas Independent Producers and Royalty Owners Association, has announced the appointment of John Davenport, former executive assistant attorney general of Texas, as general counsel of the association.

"Davenport brings to the association a broad experience in both government and legal affairs," Hermann said. "He will participate actively in our program on behalf of independent oil and gas producers and owners of land and royalty income in Texas."

Davenport served as administrative assistant to the state highway engineer for six years prior to appointment by Price Daniel as assistant attorney general in 1952. Former Attorney General John Ben Shepperd named him executive assistant in 1954.

Davenport is immediate past president of the Texas Public Employe Association and currently serves as president of the Texas Humane Federation and the Humane Society of Austin and Travis County.

So. Calif. OIC Names 6 Vice Chairmen for 1957

Six officers who will assist in direction of the 1957 Southern California Oil Information Committee program were named recently.

Serving as vice chairmen will be: industry participation, Paul H. Jamison, Kobe, Inc.; speakers, C. C. Strickland, Standard Oil Company of California; women's activities, Louise Schock, Shell Oil Company; education, Tom Folsom, Honolulu Oil Corporation; press, radio and television, L. B. Hochstrasser, Richfield Oil Corporation; and executive vice chairman, George Weismann, General Petroleum Corporation.

The committee's "grass roots" petroleum information program is part of a nationwide educational project conducted by the American Petroleum Institute's Oil Information Committee.

Kansas-Oklahoma OIC To Be Headed by Karns

Russell D. Karns, assistant to the president of Stanolind Oil & Gas Co., Tulsa, was elected chairman of the Oil Information Committee for the Kansas-Oklahoma district.

He succeeds Robert A. Douglass, southern regional manager for the Ethyl Corporation, Tulsa, who has served for two years as district chairman. Karns was elected for the 1957-1958 term. As district chairman, he will also serve as a member of the National OIC.

Karns has been with Stanolind since 1934 and has held his present title with the company since 1944. He has been active in OIC work for a number of years and has served during the past two years as district executive vice chairman. At a recent meeting he was honored for the second year in a row as one of the recipients of the OIC's Gold Award, the highest honor that can be bestowed by an OIC district. In 1953 he was honored with a Silver Award for meritorious service.

In addition to his work with the OIC, Karns has also served two years as chairman of the Oil Progress Committee (now called the Petroleum Information Committee) of the Tulsa Chamber of Commerce.

Technical Service Branch Directed by Mattocks

Appointment of Elmer O. Mattocks as director of the Department of Technical Services of the American Petroleum Institute was announced by President Frank M. Porter. Mattocks, who has been assistant director for the past several years, succeeds David V. Stroop, who now will devote all of his time to his duties as executive assistant to the president.

The Department of Technical Services embraces fundamental research, safety and fire protection and inter-divisional activities.

Mattocks joined the Institute staff in the Spring of 1950, coming to API from Phillips Petroleum Company, Bartlesville, Okla., with whom he had been a technical representative.

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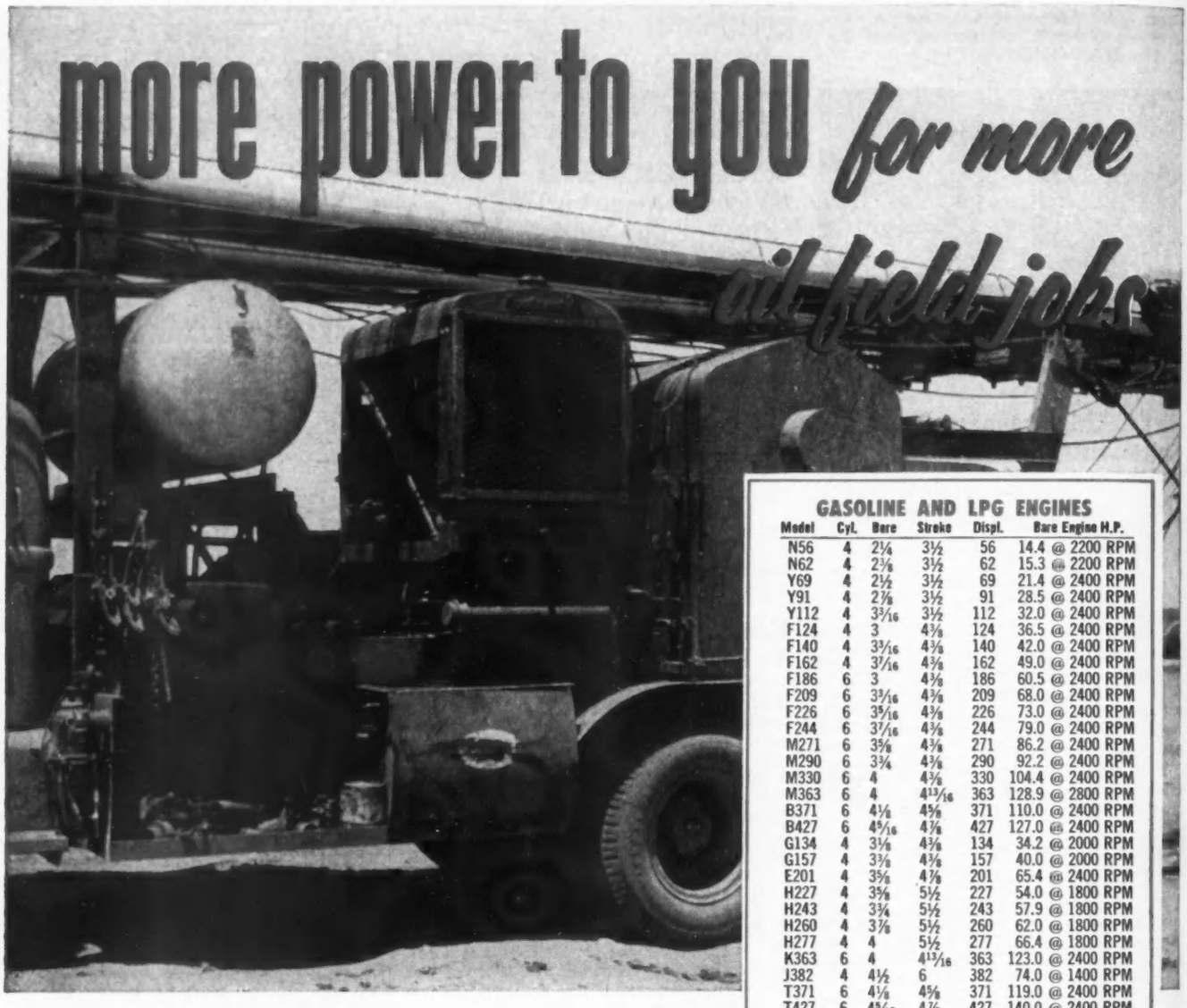

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GASOLINE AND LPG ENGINES

Model	Cyl.	Bore	Stroke	Displ.	Bare Engine H.P.
N56	4	2¼	3½	56	14.4 @ 2200 RPM
N62	4	2⅜	3½	62	15.3 @ 2200 RPM
Y69	4	2½	3½	69	21.4 @ 2400 RPM
Y91	4	2⅞	3½	91	28.5 @ 2400 RPM
Y112	4	3 3/16	3½	112	32.0 @ 2400 RPM
F124	4	3	4⅜	124	36.5 @ 2400 RPM
F140	4	3 3/16	4⅜	140	42.0 @ 2400 RPM
F162	4	3 7/16	4⅜	162	49.0 @ 2400 RPM
F186	6	3	4⅜	186	60.5 @ 2400 RPM
F209	6	3 3/16	4⅜	209	68.0 @ 2400 RPM
F226	6	3 5/16	4⅜	226	73.0 @ 2400 RPM
F244	6	3 7/16	4⅜	244	79.0 @ 2400 RPM
M271	6	3⅝	4⅜	271	86.2 @ 2400 RPM
M290	6	3¾	4⅜	290	92.2 @ 2400 RPM
M330	6	4	4⅜	330	104.4 @ 2400 RPM
M363	6	4	4 13/16	363	128.9 @ 2800 RPM
B371	6	4⅛	4⅝	371	110.0 @ 2400 RPM
B427	6	4 5/16	4⅜	427	127.0 @ 2400 RPM
G134	4	3⅛	4⅜	134	34.2 @ 2000 RPM
G157	4	3⅜	4⅜	157	40.0 @ 2000 RPM
E201	4	3⅝	4⅞	201	65.4 @ 2400 RPM
H227	4	3⅝	5½	227	54.0 @ 1800 RPM
H243	4	3¾	5½	243	57.9 @ 1800 RPM
H260	4	3⅞	5½	260	62.0 @ 1800 RPM
H277	4	4	5½	277	66.4 @ 1800 RPM
K363	6	4	4 13/16	363	123.0 @ 2400 RPM
J382	4	4½	6	382	74.0 @ 1400 RPM
T371	6	4⅛	4⅝	371	119.0 @ 2400 RPM
T427	6	4 5/16	4⅞	427	140.0 @ 2400 RPM
U501	6	4½	5¼	501	159.0 @ 2400 RPM
R513	6	4½	5⅓	513	164.3 @ 2400 RPM
R572	6	4¾	5⅓	572	182.4 @ 2400 RPM
R602	6	4⅞	5⅓	602	191.7 @ 2400 RPM
V603	8	4¾	4¼	603	220.0 @ 2800 RPM
S749	6	5⅛	5½	749	217.0 @ 2200 RPM
S820	6	5⅛	5½	820	237.0 @ 2200 RPM

CUSHIONED POWER DIESEL ENGINES

Model	Cyl.	Bore	Stroke	Displ.	Bare Engine H.P.
ZD129	4	3¼	3⅞	129	34.0 @ 2000 RPM
GD157	4	3⅜	4⅜	157	39.0 @ 2000 RPM
*ED201	4	3½	4⅞	201	45.8 @ 2000 RPM
HD243	4	3¾	5½	243	55.0 @ 2000 RPM
*HD260	4	3⅞	5½	260	59.0 @ 2000 RPM
*HD277	4	4	5½	277	63.2 @ 2200 RPM
*JD382	4	4½	6	382	72.5 @ 1600 RPM
TD427	6	4 5/16	4⅞	427	106.0 @ 2000 RPM
RD572	6	4¾	5⅓	572	154.0 @ 2000 RPM
VD603	8	4¾	4¼	603	175.0 @ 2600 RPM
SD802	6	5 5/16	5½	802	202.0 @ 1800 RPM

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GOOD EQUIPMENT IS BETTER WITH CONTINENTAL RED SEAL POWER

Companies in the News

GULF OIL CORPORATION has developed a method for "looking inside the earth" which is expected to prove of substantial value in increasing the discovery of oil.

The development translates sound into graphic form. It takes the sound waves, sent underground by seismic prospectors to probe the position of rock strata, and photographically transforms them into cross-section pictures of the underground area. The result is a detailed and accurate picture of the domes, faults and other structural features present underground. Likeness of the photographs to geologic drawings of known cross-sections is striking.

By giving prospectors the most complete information so far obtainable for outlining likely locations for oil accumulations, the method promises to materially better the odds on finding oil in wildcat explorations and in locating profitable wells in existing fields. It may also reopen some regions considered "exhausted," and convert them into new petroleum resources. This was borne out when the method recently accounted for two oil discoveries in a West Texas area previously prospected over without result. Operationally, the method adds to the speed with which prospecting data can be utilized and frees skilled manpower from the time-consuming work required to interpret the former type of seismic record.

The development is described in a technical paper by E. M. Palmer, geophysical engineer of Gulf Research & Development Company, as perfecting a 20-year research effort to see underground by aid of the seismograph.

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GREAT BASINS PETROLEUM CO. elected the following directors recently: **Arthur P. Adkisson, Dwight C. Baum, H. C. Brown, Thomas W. Evans, Ross J. Ferrar, C. G. Glasscock, Jr., R. G. Greene, Irwin R. Harris, Clinton LaTourrette, W. E. Morgan, J. R. Pemberton** and **Joseph L. Ryons.** At a meeting of the newly elected board the following officers were elected: **Thomas W. Evans**, chairman of the board; **R. G. Greene**, president; **W. E. Morgan**, executive vice president; **C. L. Cavness**, vice president, **M. H. Goforth**, secretary-treasurer; **J. B. Clark**, assistant secretary-assistant treasurer. Announcement was made by management of a farmout to Falcon-Seaboard Drilling Company of the company's 30,000 acre block in Furnas County, Neb.

•

PRODUCING PROPERTIES, INC., of Houston and Dallas announced the completion of a consolidation with **SAN JUAN EXPLORATION COMPANY** of Dallas. The combined company which will maintain its headquarters in Dallas will continue to operate in the same manner as the predecessor organizations which is primarily that of purchasing producing oil and gas properties and companies, as well as the management of properties for others and consulting work in the fields of petroleum engineering, geology and economics. The continuing company, Producing Properties, Inc., has, according to the company's statement, net oil reserves of approximately 10,400,000 barrels and 112 billion cubic feet of gas. Daily production amounts to approximately 2200 barrels of oil and condensate, and 23 million cubic feet of gas produced from 261 wells located in New Mexico, Texas, Oklahoma, Kansas, Louisiana and Alberta, Canada. In addition to its own properties, it operates and manages for others approximately 550 wells located throughout the Mid-Continent area and Canada. Included in this is the operation of Medallion Petroleums, Limited, in Calgary, Alberta. Current income of Producing Properties, Inc., which is publicly owned, is approximately $275,000 per month. Chairman of the board of the company is A. Knox Tyson of Houston; president is Robert J. Bradley, vice presidents are Virgil B. Harris, Mac D. Oliver, Lionel E. Gilly and W. Rufus Brent. The consolidation was accomplished by issuing to the San Juan shareholders approximately 550,000 shares of common stock, which leaves the company with a total outstanding of approximately 1,930,000 shares.

•

UNIVERSAL DRILLING COMPANY is a new drilling company formed in New Orleans with Louis J. Roussell as president. The company is located at 502 Whitney building. They are planning to construct an offshore drilling barge for operation in waters up to 120 feet deep along the continental shelf of the Gulf of Mexico. The group underwriting the formation of the company feel that they have found a means of overcoming the major obstacle in offshore operation—instability of equipment and the high cost of drilling. Roussell, an oil operator for some 20 years, has worked for more than three years on the development of a new type of hydraulic jack. Universal will drill on contract for operating companies in the tidelands for both a fee and a participating interest, after its barge is completed.

•

PRINCE DRILLING COMPANY, Houston drilling contracting firm, have been purchased by a newly-organized company, **Prince Marine Drilling and Exploration Co. Z. C. Ambrose**, president of the new firm, indicated that Prince Marine would continue in the oil well drilling business substantially as did the predecessor company, with no significant changes in personnel anticipated. At the same time it was announced that **Dewey K. Davis**, formerly drilling superintendent for Penrod Drilling Company had resigned to join Prince Marine. Davis, who had been with Penrod since 1933, will direct operational activities of Prince Marine. Equipment acquired by Prince Marine in the purchase includes two submersible inland drilling barges of about 16,000-foot capacity and two land rigs of about 12,500-foot capacity, plus miscellaneous boats, gear and automobiles. The new company also acquired from the Prince Interests some producing acreage involving three oil wells and 13 gas wells in six Texas fields. Officers of Prince Marine Drilling & Exploration Co. include Ambrose, president; Davis, vice president and general superintendent; and **James B. Griffin**, secretary and treasurer. Directors are, in addition to Ambrose and Davis, **David C. Bintliff, H. J. Mosser, H. V. Sherrill, Jack G. Taylor, A. Knox Tyson, C. R. Williams**, and **John H. Wimberly.**

•

FRANKFORT OIL COMPANY'S headquarters and administrative offices were moved from Bartlesville, Okla., to Dallas **Carroll M. Bennett** said. Bennett, head of Bennett, Osborn & Hall, Dallas management firm, is a member of the board and director of oil operations for Distillers Corporation-Seagrams, Ltd. Frankfort is a division of Calvert Distilling Company, a Seagrams subsidiary. **Harry H. Mack**, former production vice president of Sunray Oil Company, will be general manager of operations, Bennett said. **Dolph Simic**, former exploration manager of Bay Petroleum Company, Denver, will head the Exploration department, and **Tom P. Brooks**, formerly of Southern Production Company, Fort Worth, will manage production.

•

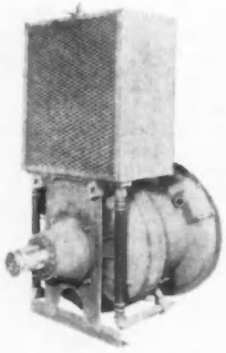
THE MESA PETROLEUM COMPANY, INC., of Wichita, Kansas, received permission from the Railroad Commission of Texas to install a modern secondary recovery system by waterflooding the Yates sand (1300' horizon) on its 850 acre lease block in the Howard-Glasscock field in Howard County, West Texas. All allowables are being transferred enabling the company to market the additional oil produced. Sunray Mid-Continent, Magnolia, Continental and others are using this method in this same field.

•

MILNER-WHITE OIL COMPANY has been formed by **R. E. Dumas Milner, Harold R. White** and **Julian Alexander** with offices in the Milner building in Jackson, Miss. The new company will engage in general oil operations, primarily in Mississippi and the southeastern states. Milner is engaged in various enterprises, including manufacturing companies, office buildings, automobile dealerships, a radio station, two large hotels and others. He was the recipient of the 1956 Horatio Alger Award. White, an independent consulting geologist in Jackson for the past two years, was previously with Seaboard Oil Company for two years as district geologist in Jackson, and was with Pure Oil Company in New Orleans for four years. Alexander is presently engaged in general legal practice in Jackson. He was district attorney for a number of years.

•

BLUE WATER DRILLING CORPORATION, owned by Olin Oil & Gas Corporation, Mississippi River Fuel Corporation, Austral Oil Exploration Company Incorporated and Crescent Drilling Company, Inc., was organized recently. Blue Water Drilling Corporation, a Delaware corporation, will engage in contract drilling in the Gulf of Mexico offshore area. A mobile drilling barge, similar to Kerr-McGee's "Kermac 46," is to be built by the new concern. The giant submersible drilling barge, tallest floating structure in the world, is designed to operate in waters up to 70 feet in depth. The keel was laid February 15 at Ingalls Shipbuilding Company's shipyard at Pascagoula, Miss. and will be commissioned and ready to engage in offshore drilling by August 1, 1957. **Harold F. Moses**, president of Olin Oil & Gas Corporation, will be president of the new offshore drilling concern. Other officers are **Ray V. Terry, E. F. Blanks** and **C. Wardell Leisk**, vice presidents, and **D. J. Miles**, secretary-treasurer.



***Left.* 16,000 Series Three-Stage Torque Converter**

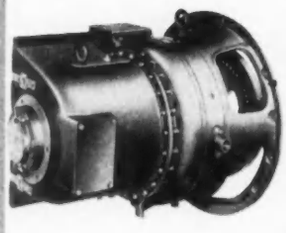
Will transmit up to 1000 hp at 1500 rpm. Seven specific torque ratings from 260 to 600 lb.-ft. SAE 00 flywheel housing size or clutch between flywheel and converter.

***Left.* 13,800 Series Three-Stage Torque Converter**

To 600 hp at 1800 rpm. Eight specific torque ratings from 230 to 540 lb.-ft. SAE 00 or 0 flywheel housing sizes. Spider drive or clutch between flywheel and converter. Output shaft takes full sidepull.

***Right.* 11,500 Series Three-Stage Torque Converter**

From 60 hp at 700 rpm to 425 hp at 2200 rpm. Six specific torque ratings from 230 to 450 lb.-ft. SAE 0 or 1 flywheel housing sizes. With or without clutch. Full range of input-output combinations available.



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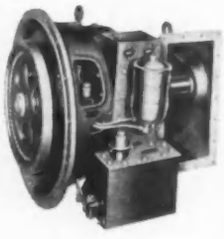
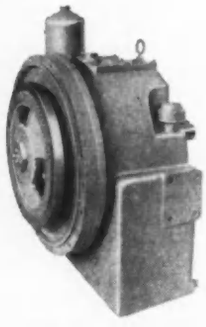


***Left.* 10,000 Series Three-Stage Torque Converter**

From 40 hp at 700 rpm to 335 hp at 2400 rpm. Eight specific torque ratings from 200 to 500 lb.-ft. SAE 1 flywheel housing size. With or without clutch. Full range of input-output combinations available.

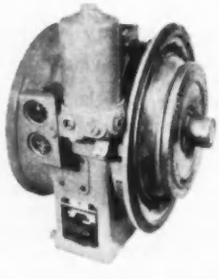


***Left.* 1500 Series Single-Stage Torque Converter**

From 30 hp at 1100 rpm to 207 hp at 2500 rpm. Five specific torque ratings from 165 to 330 lb.-ft. SAE 1 or 2 flywheel housing sizes. With or without clutch. Various input-output combinations available.

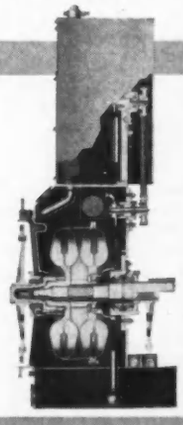
***Right.* 1300 Series Single-Stage Torque Converter**

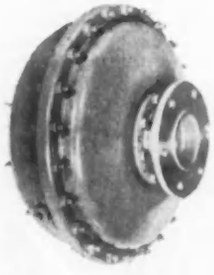
From 30 hp at 1450 rpm to 212 at 3200 rpm. Five specific torque ratings from 165 to 330 lb.-ft. SAE 2 flywheel housing size and SAE 2 or 3 output spacer housing. Output adaptable to Twin Disc SP-111 PTO.



***Right.* Disconnecting Fluid Power Take-Offs**

Model 27 HUD for engines to 850 hp at 1525 rpm. SAE 00 flywheel housing size. Model 21 HUD for engines to 580 hp at 1900 rpm. SAE 0 flywheel housing size. Both models equipped with radiator and fan and output shafts permit full sidepull.





***Left.* Fluid Couplings and PTO's**

Fluid Couplings from 7.4 to 27 inches, to 850 hp. Speeds to 5400 rpm. Fluid Power Take-Offs in 21, 17.5 and 14.5-inch sizes, to 500 hp. Speeds to 2700 rpm. SAE 0, 1 and 2 sizes. Ideal for high inertia loads and cushioning out shocks and damaging pulsations.

***Left.* HYDRO-SHEAVES®**

Combine fluid drive benefits with V-belt economy and convenience. For pumping jacks, shale shakers and many other oil field applications. Permit smaller motors, minimize equipment wear, reduce power factor. Fractional to 50 hp at nominal motor speeds.

Oil field equipment manufacturers, owners and operators look to Twin Disc for

unbiased

recommendations because . . .

Twin Disc—and *only* Twin Disc—offers a complete line of fluid and friction drives . . . three-stage and single-stage torque converters from 30 to 1000 hp . . . fluid couplings from fractional to 850 hp . . . friction clutches and power take-offs to 1050 hp.

Regardless of the oil field equipment or machinery application, you can depend upon Twin Disc products for the most efficient and profitable means of transmitting power.

For high-capacity mud pumps, rotary tables and drawworks, Twin Disc Three-Stage Torque Converters prove ideal. Providing up to 6:1 torque multiplication, the three-stage torque converter continually compensates for varying load conditions within a wide application range.

Where maximum torque multiplication is not required, Twin Disc Single-Stage Torque Converters, multiplying torque up to 3:1, are widely accepted in oil field applications. These units are excellent for transmitting power on shallow hole drilling jobs, oil field service equipment and other power installations where mild torque conversion is required.

Where torque multiplication is not necessary, oil field equipment can still benefit through the use of Twin Disc Fluid Couplings and Fluid Power Take-Offs. These permit full input torque to be transmitted at all times, regardless of load conditions. Like torque converters, their fluid connection dampens out harmful vibrations and shock loads, thus relieving equipment from stresses and strains that eventually result in downtime. The fluid's "slip" characteristic compensates for sudden overloads.

Twin Disc's line of friction clutches is built for all oil field equipment where friction drives lend themselves most profitably. These units are adaptable to air, hydraulic and manual operation, thus meeting the widest degree of oil field requirements.

Write to Twin Disc Clutch Company today or see your local Twin Disc Dealer . . . for unbiased recommendations on the type of drive best suited for your specific oil field equipment.

Twin Disc Clutch Company, Racine, Wisconsin; Hydraulic Division, Rockford, Illinois . . . with parts and service facilities throughout most of the world.

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What's Happening

AMONG SERVICE AND SUPPLY MEN

Arthur Weber

C. C. Crider

C. R. McNair

E. G. (General) Lee

James Bayliss

William J. Alexander

J. B. Roberts

William Sivyer

H. F. Bergis

Sam Wilson

Owen J. Higgins

L. C. Daniels

C. C. Crider has been appointed general manager of stores for **Bethlehem Supply Company.** Succeeding Crider as central division sales manager is **Arthur Weber, Jr.,** who has been district manager of the West Texas-New Mexico district since 1953, located in Midland, Texas. Replacing Weber is **C. R. (Rufus) McNair,** who has been division machinery sales representative in the Gulf Coast division office at Houston. Crider has been a division sales manager for Bethlehem Supply Company since 1939. His experience in the supply business dates back to 1922, at which time he assisted in the organization of the Taubman Supply Company, which was purchased by Bethlehem Supply in 1937. Coincident with this appointment, Bethlehem will move their Central division office to Fort Worth, Texas, and will be located in the new Continental Bank building. Weber, who became Central division sales manager at this point, joined Bethlehem Supply in 1942 as sales engineer in the Tulsa office. In 1949 he was transferred to Midland as special representative for the West Texas-New Mexico district and has held that position until now. McNair came to Bethlehem Supply in 1948 from the Stanolind Oil & Gas Company, where he was junior mechanical engineer. In 1949 he was promoted to machinery sales representative, specializing in production equipment and waterflood engineering. He was promoted to division machinery sales representative and transferred to the Gulf Coast division office in Houston in June of 1955. McNair's headquarters are in Midland.

•

General Chemicals, Inc. announced the appointment of **E. G. (General) Lee** as president. Prior to his association with General, Lee was manager of oil field sales for the Diamond Alkali Company. The new General Chemicals will specialize in a line of products designed for the oil industry.

•

Cameron Iron Works, Inc., of Houston has announced the appointment of **James Bayliss** as sales and service representative for New Zealand, Australia, British and Dutch New Guinea and the Philippine Islands. Bayliss entered the petroleum industry in 1919 working in Wyoming and Oklahoma, first as a roustabout and then as a tool dresser and cable tool driller.

In 1925 Bayliss went to Persia with the Anglo-Persian Oil Company. He has served as roughneck, cable and rotary driller, tool pusher and equipment engineer for British Burma Petroleum, Anglo-Iranian Oil Company and Shell, in Burma, England, Scotland, Trinidad, Egypt and Australia. Joining Tutt-Bryant, Representatives, in 1950, Bayliss represented National Supply Company, George E. Failing Supply Company and Reed Roller Bit Company in Australia. He started his own firm in August, 1953, with headquarters in Brisbane, Australia.

•

Continental-Emsco Company, a division of Youngstown Sheet and Tube Company, has appointed **William J. Alexander,** manager of their newly-organized Sales Promotion department. The new department will coordinate all sales promotion, advertising and public relations activities of Continental-Emsco, including convention activities, exhibits and demonstrations, public appearances, introduction of new products (sales bulletins), sales letters, trade paper advertising and publicity. Alexander was formerly advertising manager of Emsco Manufacturing Company in Los Angeles until that company and Continental Supply Company were merged last January to form Continental-Emsco Company.

•

Chain Belt Company has announced these promotions. Three new regional sales managerships have been created—for the Eastern; Midwest and Southern, and Northwestern regions; two new district sales offices have been opened; and six new district sales managers have been appointed. **J. B. Roberts,** formerly New York district sales manager, becomes Eastern regional sales manager. **William Sivyer,** formerly Philadelphia district sales manager, becomes Midwest and Southern regional sales manager. **H. F. Bergis,** formerly Portland district sales manager, becomes Northwestern regional sales manager. New district sales offices are being created at Newark, N. J., and Charlotte, N. C. The latter has been an area office. **J. S. Moore** becomes district sales manager at New York City. He formerly held this position at Atlanta. **H. F. Weil** becomes district sales manager at Philadelphia, Penn. He was district sales engineer at New York City. **Dabney P. Murrill** becomes district sales manager at Atlanta, Ga. He was district sales engineer in that office. **Wilbur F. Church** becomes district sales manager at Portland, Ore. He was district sales engineer in that office. **Raymond F. Traylor** becomes district sales manager at Charlotte, N. C., of the new district sales office being created there. He was formerly district sales engineer. **C. D. Bergen** becomes district sales manager of the new district sales office at Newark, N. J. He was a district sales engineer at New York City.

Give You "More Use per Dollar"

Ray-Man Rotary Hose Handles Easiest on the Rig

. . . and *safest*, too. R/M's method of applying high tensile steel cable wires under precisioned tension makes Ray-Man CBL Rotary Hose unequalled for strength, flexibility and safety. It holds steady in the derrick without whipping . . . even under the high-pressures of deep drilling. And when it comes to moving from location to location Ray-Man's flexibility and light weight minimizes the dangers of accidental crushing and kinking in transport . . . assures easier, faster rigging up on the next job.

Ray-Man's streamlined, built-in coupling adds to your safety on the job, too. Designed without protruding lugs or flanges that cause fouling, it features R/M's special leak-proof "Lip-Lok" seal that actually tightens under pressure to prevent dangerous — and costly — blow-outs!

Add Manhattan's oil-proof tube for drilling-in with oil or oil-base and you've got easier, safer handling and longer, trouble-free services at less cost on *every* drilling job . . . with Ray-Man CBL Rotary Hose.

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You'll find "More Use per Dollar" features in these R/M hose constructions, developed especially for oil field service:

Manhattan Mud Pump Intake Hose — designed with Type 'C' Leakless Built-In Nipples for rough service with the most powerful mud pumps.

Manhattan Geophysical Hose — dependable strength, longer service in drilling small test wells.

Ray-Man Rotary Vibration Hose — to withstand high pressures between mud pump and rig standpipe.

Discuss your hose needs with an R/M representative.

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Sam A. Wilson has organized his own company to function as a consultant and manufacturers representative. At present the company is experimenting with a new gas dehydrator. It will specialize in natural gas processing and lease equipment. Previously, Wilson was employed by Dunham Tank Company. He is a registered professional engineer.

•

L. C. Daniels is now general manager of the Buda division, Tractor group, **Allis-Chalmers Manufacturing Company,** and **Owen J. Higgins** is general manager of the Harvey, Ill., works where the Buda division's material handling equipment and Diesel, gasoline, L P Gas and gas engines and generator sets are manufactured. Daniels succeeds **R. K. Mangan**, president and general manager, Buda division, who retired Jan. 1, 1957. Daniels joined the Buda Company as vice president in 1950 after a long career in the automotive industry with truck, bus, tractor and material handling companies. When Allis-Chalmers acquired the Buda Company in 1953, he continued to be responsible for the material handling, industrial and railroad products of the company. Higgins started with the Monarch Tractor Co., Springfield, Ill., in 1926. This company was acquired by Allis-Chalmers in 1928 and became its Springfield works where crawler tractors and allied equipment and motor graders are manufactured. He was transferred to the Company's harvesting machine plant at La Porte, Ind., as assistant works manager in 1943 and promoted to assistant general works manager of the Tractor group in 1950 with headquarters in Milwaukee.

Ed Fain

G. S. Dietz

Ed Fain has been named vice president and general manager of **Eastman International Company,** whose main offices are in Denver. He has worked in the oil business for 18 years, and has had considerable experience in various phases of the industry, both domestic and foreign. He first took a job with Geophysical Service, Incorporated. During the 10 years he worked with this corporation, Fain held several field positions, working as observer, computer, relief party chief, and in the laboratory, on instrument design and building. He worked for GSI in the U. S., Mexico, Venezuela and India. In 1941, Fain took a job as instructor and engineer for Aviation Enterprises, in Houston.

•

G. S. Dietz has been promoted to assistant cashier in the Oil and Gas division of the **First City National Bank of Houston.** Dietz joined the bank as a petroleum engineer in 1951. He was formerly senior petroleum engineer for Stanolind Oil and Gas Company, having been associated with the company for 15 years.

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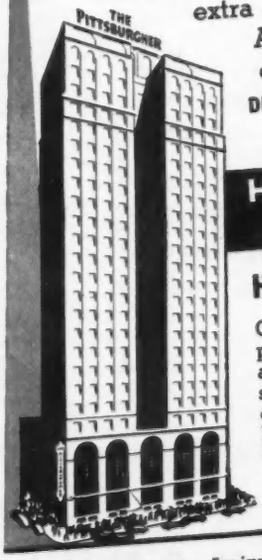

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Joseph F. Duddy, Gen. Mgr.

Frank B. Gray, Jr.

Alton A. Dunaway

T. N. Shults

H. T. Hamm

Frank B. Gray, Jr., has joined the **Caran Engineering Corporation** of San Antonio, Texas, as chief engineer in charge of the Spectra-Graph or Spectrometric Well Logging division. Gray served as head of the Applied Physics group for Leeds & Northrup Co. in the development of spectrometric instrumentation for classified armed forces contracts and industrial applications for the chemical and petrochemical fields. His 18 years of experience as research physicist in electronics is being applied to the development of new spectrometric techniques for accurately identifying and measuring hydrocarbon gases from oil well drilling muds.

•

Alton A. Dunaway has been appointed assistant vice president of distribution operations of **Continental-Emsco Company.** He joined Continental Supply Company in 1936. He has performed credit work throughout the Mid-Continent area and has served from 1951 as assistant credit manager and assistant treasurer. Dunaway's new duties involve the distribution functions of Continental-Emsco district and division operations in the U. S. and Canada.

•

T. N. Shults, manager of **Mid-Continent Supply Company's** Export division, has been named vice president—export for the company. Shults has been in Mid-Continent's Export division in New York for the past 10 years and has been manager of the Export division since 1952. He is a veteran in the oil field supply business with 19 years experience, 17 years of it with Mid-Continent. Vice president Shults joined Mid-Continent in 1939 at the company's Fort Worth headquarters. He later was at Mid-Continent locations in Kermit, Texas, and Tulsa before moving to New York as sales engineer in 1947.

•

Houston Oil Field Material Company has appointed **H. T. Hamm** to the office of comptroller. He has been associated with Homco for 18 years, coming to this office from the position of chief cost accountant.

Houston Oil Field Material Company, Inc., has made eight promotions and personnel changes. **J. W. (Mutt) Caskey** has been named assistant division manager at Casper, Wyo. Formerly, he was district manager. **E. W. Konnerup,** store manager at Kimball, Neb., is now district manager of Kimball, Casper and Billings with headquarters in Casper. **Bill Baker,** former field salesman, is store manager at Kimball. New resident manager at Edmonton, Alberta, Canada, is **Paul Mentzel,** advanced from the position of field salesman at Billings, Mont. Also newly stationed in Billings is **Donald Carlson** who is a field salesman. District manager over the San Juan-Paradox Basins with headquarters in Farmington, N. M., is **W. S. George.** George, former store manager at Farmington, was replaced there with **Dewey Watkins.** Named city salesman in Denver, Colo., was **Lowell Harris,** formerly field salesman at Farmington.

•

The Milwhite Mud Sales Company has announced the appointment of **William C. Browning** to the post of research director. Browning will head up all phases of research and development at the drilling mud company's laboratories in Houston. Browning is best known for his work with surface active agents, rheology, deflocculation, emulsification and other phases of colloid chemistry. He comes to Milwhite after 17 years with the Marathon Corporation at Rothschild, Wis., where, as research associate, he directed all of that

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More Footage at Lower Cost—

use

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Drilling Stems

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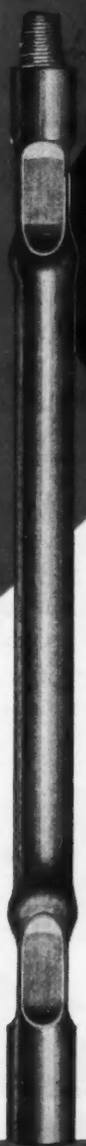

SPANG DRILLING STEMS are made of machine straightened special bar quality open hearth steel, of the right analysis to assure the greatest vibration dampening effect. Box and Pin joints are hammer-welded, fully heat-treated, and have precision machined threads to provide the strongest, most wear-resistant joints obtainable. As a result SPANG DRILLING STEMS, with high strength joints, give longer than average service and drill more footage at lower cost.

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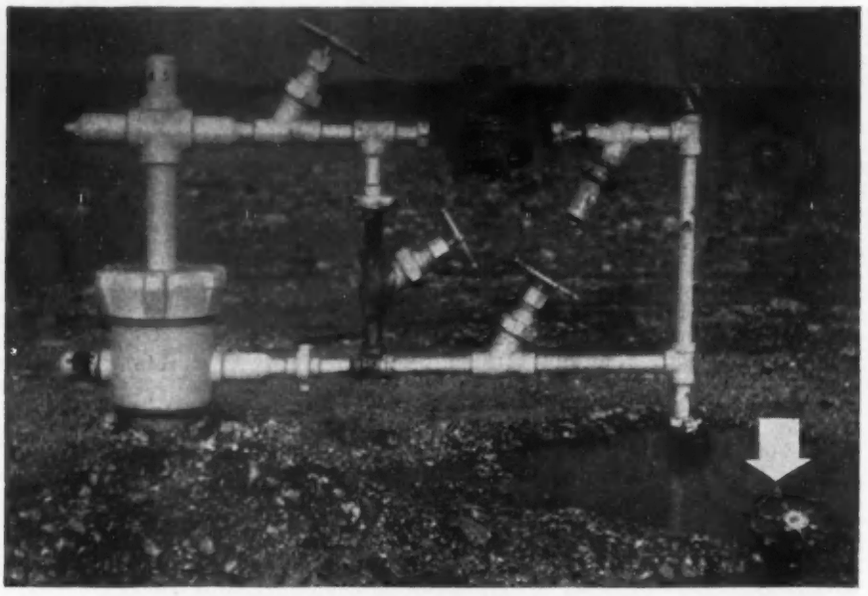
For over 60 years Manufacturers of Spang Weldless Jars and a Complete Line of Cable System Drilling and Fishing Tools for Oil and Gas Wells, Water Wells, Prospect Drilling and Shot Blast Holes.



The right steel valve can

CUT MAINTENANCE COSTS

on water flood projects

It's easy to go wrong on valve selection for water flood injection well service. In West Texas, (note field conditions in photo above—one Edward globe valve installed below ground level) and elsewhere too, weatherproof valves are needed. Blowing sand, sun and rain increase valve maintenance—frequently make valves inoperative.

For this service Edward recommends **Fig. 2698 forged steel, inside screw** globe valve (see illustration below) **with bonnet exterior EValized** (corrosion resistance plated) **and precision built interior. Only the packing nut thread is exposed and this thread can't rust. Suitable for throttling,** this low cost valve can be installed and forgotten. Make sure you aren't paying good money for the wrong *type* valve on water flood projects. Get free, *expert* assistance. Contact your nearest Edward oilfield representative, or your favorite oilfield supply store.

THESE FEATURES SAVE YOU MONEY!

Free flowing, no pockets to collect sediment!

EValloy stainless steel seats and disks borized in mated pairs!

EValized bonnet, with corrosion resisting threads!

Centerless ground stem for long packing life!

Easy packing adjustment!

Oversize handwheel for easy operation!

Forged steel bodies and bonnets!

Fig. 2698—
2000 lb WOG
Globe
Stop Valve

Edward Valves, Inc.

Subsidiary of

ROCKWELL MANUFACTURING COMPANY

1214 WEST 145TH STREET EAST CHICAGO, INDIANA

company's experimental work in the field of drilling fluids. Several patents connected with synthetic rubber, dispersing agents and drilling compounds have been issued in his name.

W. J. DuBose

C. E. Bogle

W. J. DuBose has been appointed district logging engineer for southern Louisiana with headquarters in New Iberia as announced by the **McCullough Tool Company.** DuBose, who has had extensive oil field experience, joined McCullough in January, 1956, as a sales engineer at Harvey, La. Primarily responsible for coordinating all McCullough radiation well logging studies in southern Louisiana, DuBose will also be available to assist and advise geologists, engineers and operators in their well completion programs.

•

A new wire rope section has been incorporated into the sales organization of **Jones & Laughlin Supply division** at its Tulsa headquarters office. **C. E. Bogle** has been appointed to the newly created position of manager—Wire Rope section.

Bogle, formerly in charge of wire rope sales in the Rocky Mountain area for Jones & Laughlin Steel Corporation, enters the Supply division's administrative sales staff with many years of experience in the oil country wire rope business.

In his new assignment, Bogle will concentrate on the promotion of wire rope sales through the firm's comprehensive field sales force and will report to **W. O. Hardy,** sales manager of general products.

•

William L. Butler has been elected president of **W. C. Norris Manufacturer, Inc.,** according to an announcement made by **E. C. Bolger,** retiring president. Butler joined W. C. Norris in 1935 and, prior to his election as president, has held the office of executive vice president. Bolger was president of the company during the years 1946 through 1956. Other officers of the company are **G. W. Davidson,** vice president—sales; **R. A. Colgin,** vice president—manufacturing; and **Charles Huffman,** secretary-treasurer.

•

Harold Vance, vice president and manager, Oil and Gas department, **Bank of the Southwest,** was invited to participate as a lecturer for a course offered senior and graduate students in the Petroleum Engineering department of The University of Texas. Vance appeared before the class on February 25 and discussed "Financing Oil Production." Lecturers for the course are selected from throughout the petroleum industry, and only the best qualified experts are picked to present the various topics throughout the semester.

•

Baroid Division, National Lead Company, has announced the transfer of **C. Y. Vallance** from the Rocky Mountain area and his appointment as district superintendent with headquarters at Beaumont,

NOW!

J&L Buttress-Thread Casing

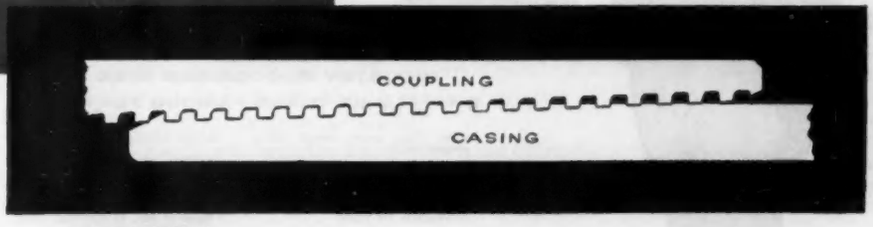
has high strength joint for toughest deep well drilling

High joint strength of J&L Buttress-Thread casing is attained by combined effect of completely engaged runout threads and the three-degree flank angle of the thread. Joint strength is almost equal to that of the body of the pipe.

Easy stabbing, rapid spinning and fewer power strokes to pull the coupling up to the power-tight position are provided by the unique thread design.

A superior casing is assured through use of quality steel, automatically controlled heat treatment, and new precision methods of machining, inspection and testing. Buttress-Thread casing is available in A.P.I. grades J-55, N-80 and P-110 as well as in still higher grades to meet special requirements.

Order this new J&L casing for use in your most severe and variable drilling operations. Write for complete information to the Jones & Laughlin Steel Corporation, Dept. 417, 3 Gateway Center, Pittsburgh 30, Pennsylvania.



Coupling threads (five per inch) engage casing threads throughout the entire length of a long coupling. The ¾ inch taper per foot is continuous and without the conventional fast angle vanishing threads. Full section of the casing is utilized in supporting weight of the string. Inside clearance of joint is not reduced by inside upsets.

J&L STEEL

Jones & Laughlin

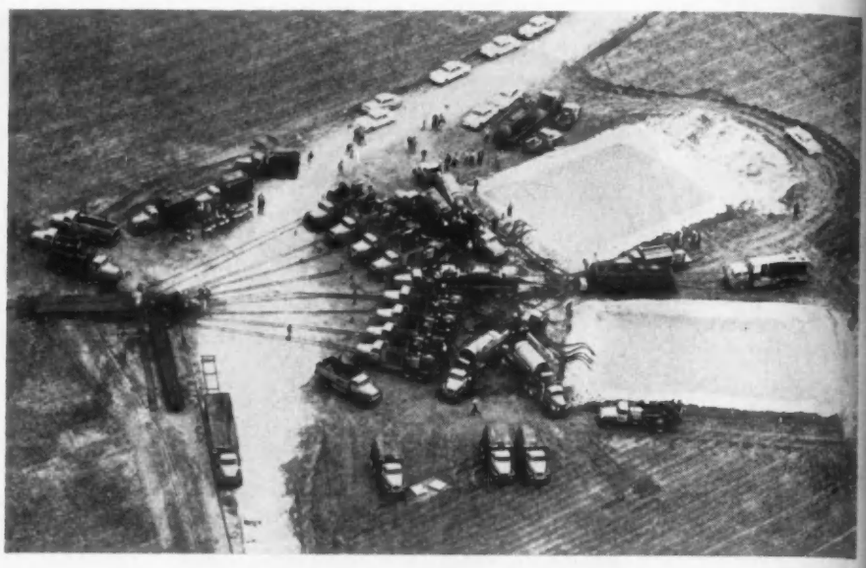
. . . a great name in steel

For more data on advertised products, use Readers' Service Cards, last page.

Texas. Vallance replaces **J. A. Brooks** who has been transferred to Hattiesburg, Miss., as district superintendent. **B. F. Stiba,** formerly at Hattiesburg, has been transferred and appointed sales representative in the New Orleans area office. **A. E. Milligan,** formerly service engineer at Shreveport, La., has been appointed district sales representative in that district; and **W. T. Sherman,** service engineer at Lake Charles, La., has been transferred and appointed sales representative, West Texas area, with headquarters in the Midland area office.

•

C. A. Pigg, formerly store manager and field representative at San Angelo, Texas, has been transferred with the same title to Graham, Texas. **J. R. Murray,** formerly field representative at San Angelo, Texas, has been promoted to store manager and field representative at that point for Bethlehem Supply Company.



Dowell's fracturing job in West Texas.

"I've ALWAYS preferred KING GA SWIVELS"

KING SWIVELS 32GA and 53GA have been popular for many years. They have proved to be rugged, dependable and durable, and are in use around the world because they are 'preferred'.

The fact that King Oil Tools is the largest manufacturer of lightweight swivels is supporting evidence of King engineering, service efficiency and complete all-around dependability.

INDUSTRY RECOGNIZES KING GA SWIVELS BY THESE FAMOUS FEATURES:

- ALLOY STEELS assures strength with minimum weight.
- PACKING is V-type, often called chevron type.
- WASHPIPES are seamless alloy tubes, case-hardened and ground.
- GREASE LUBRICATION for the packing.
- MULTIPLE BALL BEARING UNITS provide ample capacity.
- OIL BATH LUBRICATION for the bearings.
- Choice of BAIL OR ELEVATOR SHANK.

FOR FULL INFORMATION ON ALL KING SWIVELS — SEE YOUR NEAREST DISTRIBUTOR — OR WRITE:

KING OIL TOOLS

P. O. BOX 15146 • HOUSTON 20, TEXAS • ORchard 3-3421

Dowell Fractures Record Well For Tennessee Gas Transmission

Dowell Incorporated broke its own world's record for oil well fracturing recently when 41 engineers and operators with 29 pieces of equipment teamed up to inject 328,000 gallons of water and 225,000 pounds of sand into a Tennessee Gas Transmission Company well in Borden County, West Texas.

The job, which Dowell engineered to coax a greater flow of oil out of the Dean sand in the Pennsylvanian section just above the Spraberry, broke records other than in the amount of water and sand used. Only one hour and 50 minutes of pumping time was required, which means that the average injection rate was 71 barrels, or almost 3000 gallons, a minute. Surface working pressure was 3500 pounds per square inch.

Gross horsepower at the wellsite totaled 15,000 and hydraulic hp amounted to 6250.

The previous fracturing record was established by Dowell in July of last year when 250,000 gallons of water and 200,000 pounds of sand were injected into a well in the Spraberry area near Midland. On that Riverfrac project, the water and sand slammed down into the well at an average injection rate of 52 barrels a minute under a surface working pressure of 3400 psi.

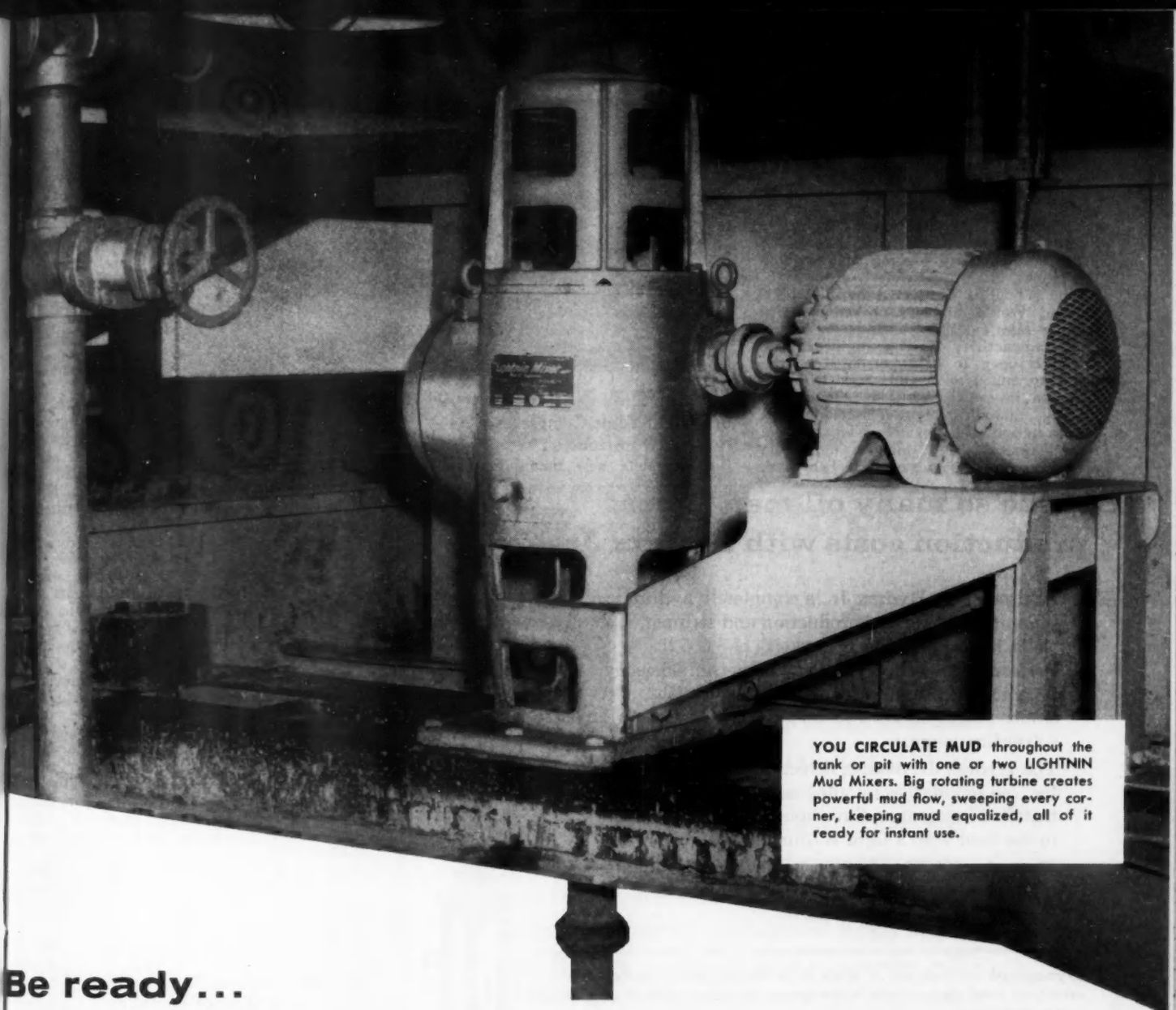
The well, the Number 1 Thomas, 21½ miles south and east of Lamesa and 21½ miles north and east of Big Spring, is producing from about 8200 feet.

Jack Sutherlin is manager of Dowell's Wichita Falls district which was responsible for the job. Engineering assistance also came from the Midland district. Service engineer in charge of the record project was Earl Spiller.

Eight Complete Logging School Held by Welex Jet in Fort Worth

Eight men of the West Texas and Rocky Mountain divisions of Welex Jet Services, Inc., have satisfactorily completed a radioactivity logging school held at the Welex Lodge near Fort Worth, Texas.

Graduates of the second weekly course conducted by Welex were: L. M. Robertson, manager of the Kimball, Neb., dis-



YOU CIRCULATE MUD throughout the tank or pit with one or two LIGHTNIN Mud Mixers. Big rotating turbine creates powerful mud flow, sweeping every corner, keeping mud equalized, all of it ready for instant use.

Be ready...

with mud you can change in seconds!

Here's how: Use this amazingly fast new way to get mud in condition—and keep it there.

On drilling tenders off the Gulf Coast—on the world's deepest holes—all up and down the oil country, drilling men are getting an *immediate* rise in mud weight when they want it.

You can, too. When you mix your mud with LIGHTNIN Mixers, you can increase the weight of every gallon of mud in the tank or pit, by the exact amount you want—*in a few seconds.*

You get *immediate dispersion* of gel additions—and fully uniform viscosity in minutes.

When you need heavier, thicker mud, *it's there*—ready for instant use.

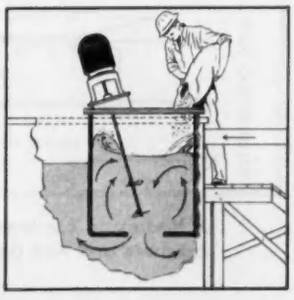
Cut maintenance, too

You gain in many other ways, too, with LIGHTNIN Mixers in your mud tanks or mud pits. You use *less* mud; put *less* demand on your pumps; spend *less* on equipment maintenance. On deep holes, you can eliminate the entire cost of a third mud pump.

You take no risk when you choose LIGHTNIN Mixers. Every LIGHTNIN is unconditionally guaranteed to do the mixing job right.

See for yourself why LIGHTNINs can give you better mud control—for less money. Ask your LIGHTNIN sales engineer (listed in Composite Catalog) to arrange a visit to a rig in your area so you can see LIGHTNINs at work.

And for quick facts on LIGHTNIN mud control, send us a postal today requesting free illustrated Bulletin B-502.



YOU FLASH-MIX weight and gel additions into the mud through a LIGHTNIN Flash Mixer. High-speed propellers break lumps and give instant dispersion of weight and gel in the incoming mud. Feed additions fast as you want—no clogging, no waiting.

MIXING EQUIPMENT Co., Inc., 197-b Mt. Read Blvd., Rochester 11, N.Y.

In Canada: Greey Mixing Equipment Ltd., Toronto 10, Ont.

Lightnin Mixers

trict; L. M. Wood, assistant manager of the Abilene, Texas, district; H. D. Foster, assistant manager of the Wichita Falls, Texas, district; E. M. Elbert, assistant manager of the San Angelo, Texas, district; Jerry Rushmore, assistant manager of the Pampa, Texas, district; C. C. Seamon and E. B. David, sales engineers, Farmington, N. M., district; and J. C. Willis, radioactivity logging operator for the Hobbs, N. M., district.

The school is conducted by Floyd D. Sawyer, Welex manager of radioactivity logging sales, and L. A. Ingram, Welex chief radioactivity logging engineer. The school is open to field personnel of the company and lasts a full week with instruction in every phase of radioactivity logging, including techniques, tools and interpretation and analysis. This is the second class of eight men to finish the class since it was begun early in February.

Brown Oil Tool's Houston plant.

Brown Oil Tools Completes New Plant in Houston

A complete new manufacturing plant of more than 60,000 square feet, designed for both mass production and custom manufacturing of petroleum production and fishing tool equipment has been placed in operation by Brown Oil Tools, Inc. The plant is situated on a 65 acre tract located at 8490 Katy Road, Houston.

The large new installation is a direct outgrowth of a small business started 27 years ago by Houston's C. C. Brown, who still heads the company. After 14 years of oil field experience, Brown entered the oil equipment business in 1930, with his first development being a new type safety tubing head christmas tree. Another technique initiated by Brown was a method for setting screens and washing wells in under pressure. In the years since, the company has designed, developed, and is marketing a wide range of production items.

Brown Oil Tools, Inc. will not entirely abandon its old plant at 2216 Campbell Street in Houston, as the manufacturing facilities there will be used to turn out custom jobs.

Members of the executive staff include two sons of Brown, Joe R. and Ray L., with Carl Riesel, general manager; John R. Feeser, sales manager and L. Baker Richardson, service manager. Other employes number approximately 400.

Rockwell Expands Denver Office; Cochran Is District Manager

Rockwell Manufacturing Company's Meter and Valve division has expanded its Denver branch office into a full district office. Orville Cochran, Denver branch manager, has been promoted to district sales manager.

Orville Cochran

Cochran served as a sales engineer for Rockwell in the Rocky Mountain territory for more than 25 years before being named branch office manager in 1955, when the Denver office was opened. He joined the company in 1922, spending his first eight years in the Kansas City district office.

Alco Acquires Houston Site For Future Industrial Expansion

Alco Products, Inc. announced the acquisition of a new industrial site in Houston as the eventual production center for the company's petroleum industry equipment business. The company at the same time announced the establishment of its petroleum industry equipment division headquarters together with the relocation of its district sales offices. Additional internal organizational changes in line with

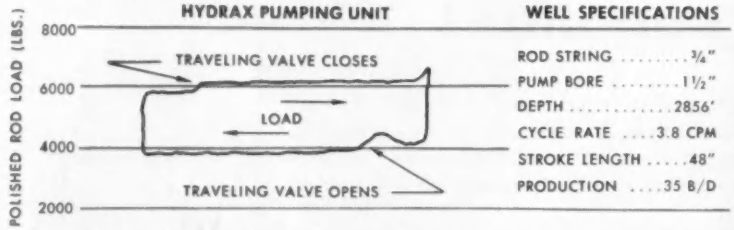
How do so many oil men lower production costs with Hydrax Jrs.?

Axelson's 4-ft. Hydrax Jr., a completely hydraulic pumping unit for low-production and stripper wells, has a polished rod capacity of 8,000 lbs. Performs slowly for greater volumetric efficiency. Smooth operation and cushioned reversals assure longer sucker rod life, more service from subsurface pumps.

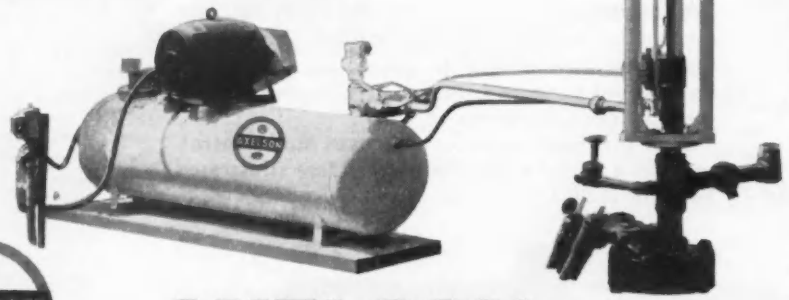
The Hydrax Jr. mounts directly on the production tee. No foundation or substructures. Can be installed in less than three hours; moved anywhere in the field with a light A-frame truck.

Controls are at production tee level. No ladders to climb for servicing, no special tools required. Hydrax dealers stock all parts.

Dynagraph card shows Hydrax Jr.'s smooth performance. Note its constant load characteristic compared to uneven loads common to beam pumpers.



A Hydrax Jr. can lower your production costs! Write for brochure and well data application sheet.



AXELSON

MANUFACTURING COMPANY

Division of U. S. Industries, Inc.

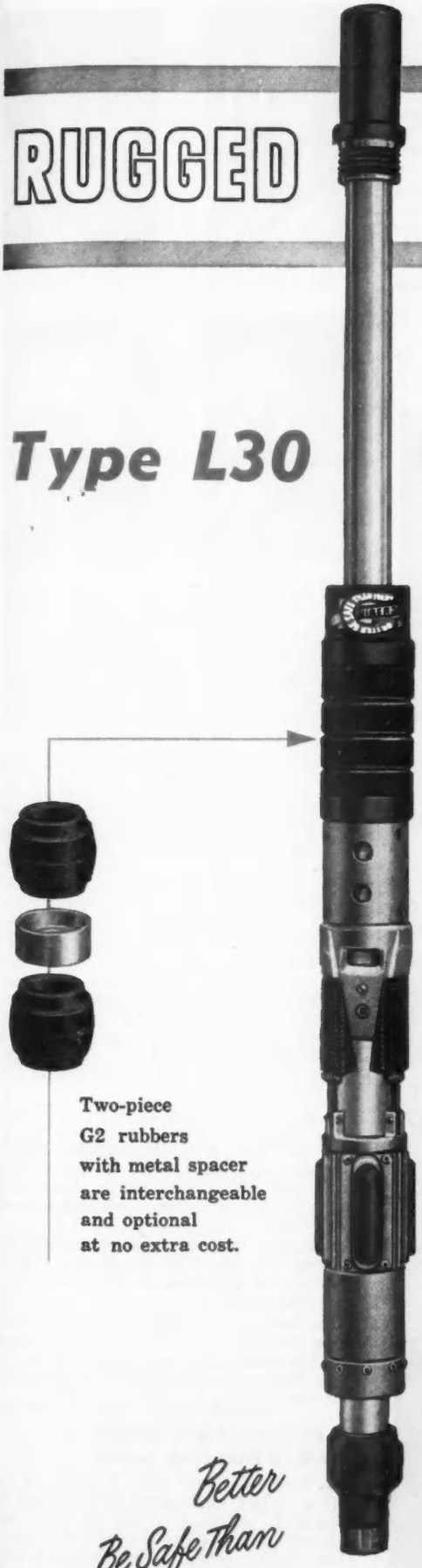
6160 South Boyle Avenue · Los Angeles 58, California

PUMPS • SUCKER RODS
HYDRAULIC PUMPING UNITS

RUGGED AND RELIABLE

GUIBERSON'S

Type L30 Deep Well Packer



Two-piece G2 rubbers with metal spacer are interchangeable and optional at no extra cost.

For deep well work with high temperatures and pressures, use Guiberson's dependable L30 Packer. It will give you long valve travel (30 inches) with minimum overall length at no extra cost. You can pull the L30 surely and safely. The fast-action automatic latch, protected by a positive anti-lock device that assures ready release, snaps easily into latched position. Tough, long-wearing friction pads supply ample drag. Packing rubbers of advanced design will not vulcanize to the casing wall. All these features are available on the L30 or the L8 with 8" valve stroke in a wide range of casing sizes. For circulating *above* the packer, Type L30P or L8P with perforated mandrel is available.

Better Be Safe Than Sorry

BETTER BE SAFE THAN SORRY
GUIBERSON

THE
GUIBERSON
CORPORATION

ESTABLISHED 1919
DALLAS, TEXAS
U. S. A.

ONE OF THE DRESSER INDUSTRIES

Sold by
Oil Field Supply Stores
Everywhere

For more data on advertised products, use Readers' Service Cards, last page.

the recent creation of the new division also were made public.

The new 107-acre industrial site is located on Almeda Road near Riley Road. It is served by the Missouri Pacific Railroad.

In discussing the acquisition, C. C. Davis, petroleum industry equipment division manager, stated that while Alco had no immediate plans for utilizing the Houston site, the company hopes to commence construction in the not too distant future. Davis added that the firm will probably start with a small manufacturing facility and then will expand here as its product operations are increased. He pointed out that the land purchased allows ample room for future expansion.

Main offices are located at New York City.

New headquarters for the Petroleum Industry Equipment division will be established on the fourth floor of the Bank of the Southwest in downtown Houston. District sales offices, formerly located at 1404 Dunlavy Street, will be maintained at the same address.

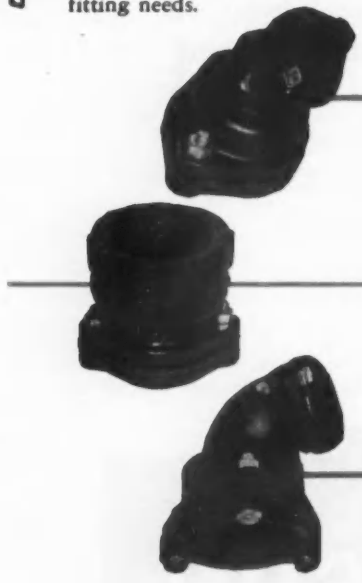
Alco first announced its administrative decentralization last fall, when the company set up four product divisions headed by general managers who report to W. S. Morris, executive vice president. Davis was named manager of the petroleum industry equipment division at that time. He formerly was Alco southwest regional manager at St. Louis.

YOU JUST CAN'T BEAT

SLIP-ON'S*!

You can accomplish maximum economy by using Enardo **SLIP-ON** fittings for all low pressure fitting installations. Some users have reported a 50% savings in time and money because of their labor saving qualities. No unions are needed with Enardo **SLIP-ON** fittings, which means easier, faster, and cheaper lease installations.

Consult your Enardo salesman or call the Tulsa office for your own particular fitting needs.



4" to 3" and 4" to 2" **SLIP-ON** 45° reducer ells. Principally designed for use in equalizer line installations.

4" N.P.T. to 3" **SLIP-ON** reducer connections. For connections between screwed end pipe and blank end pipe. Also used for water-leg installations.

6" to 4" **SLIP-ON** 90° reducer ell. General purpose fitting for installations where working pressures do not exceed 150 p.s.i.

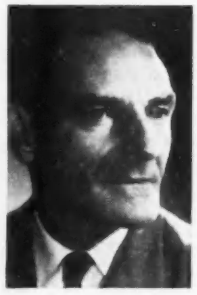
*Reg. T. M.

ENARDO manufacturing company

BOX 1347 • TULSA, OKLAHOMA

H. P. Fogle

G. W. Hunt



F. M. Morris

Carl T. Slaughter

Longhorn Supply Incorporates; Names Three Vice Presidents

Incorporation of the Longhorn Supply Company and the appointment of three vice presidents and a general manager and secretary-treasurer has been announced.

The firm, a distributor of oil field and industrial supplies since 1945, until February 1 was a partnership between G. W. (Mike) Hunt, now president, and Claude R. Whelchel, Sr. The latter recently sold his interest.

New Longhorn vice presidents are H. P. Fogle and Carl T. Slaughter, both of Houston, and E. E. Samford, Bridgeport, Texas. General manager and secretary-treasurer is F. M. Morris. Fogle has been with Longhorn since 1951. Prior to that time, he was for 16½ years associated with the Oilwell Supply Company as store manager, district manager and assistant division manager. Other past company affiliations include the Pure Oil Company, Rycade Oil Corp. and the Magnolia Petroleum Company.

A member of the Longhorn staff since 1947, Morris has been in Houston since 1943 and was with the National Supply Company for three years. He has worked in the oil industry in north Texas and Oklahoma for contractors and independent operators.

Slaughter has been with Longhorn for 11 years. He was with the Brown & Root Construction Company for four and a half years prior to that.

Samford is manager of Longhorn's Bridgeport supply outlet in Wise County and has been with the company for 10 years. He was in Houston on the city sales staff until a year ago.

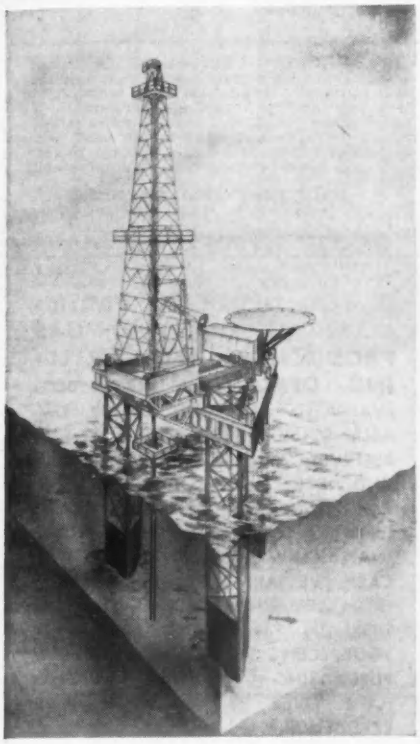
Du Pont Donates $1 Million In Aid-to-Education Grants

A fund of more than $1,000,000 for grants to 122 universities and colleges in its annual program of aid to education was announced by the Du Pont Company. This support, which is for the next academic year, is a substantial increase over the $900,000 in gifts made for this year.

Nearly all of the increase and more than half of the entire program are for the improvement of teaching in univer-

sities, colleges and high schools. The grants will support science and mathematics as well as other subjects.

The growth of the Du Pont program, as well as the change in emphasis, reflects the changing needs of the schools. At the same time, grants for fellowships in science, which once made up the entire program, and for fundamental research are being continued. Du Pont's aid-to-education program dates from 1918.



This new combination-type offshore platform, just purchased from R. G. LeTourneau, Inc., by Deepwater Exploration Co. of Houston, will be used for medium-depth holes—on workover, drilling or completion.

$1.5 Million Offshore Platform To Be Built by LeTourneau

Purchase of an offshore drilling platform, different from anything the offshore industry has yet seen, was announced by R. G. LeTourneau, Inc.

Deepwater Exploration Company of Houston has awarded LeTourneau a contract to build the combination-type platform, at a cost in excess of $1.5 million, with delivery set for June of this year.

In making the announcement, R. L. LeTourneau, vice president of the heavy equipment firm, said the new platform will answer the industry's need for medium depth holes—on workover, drilling or completion. He noted that, as only one feature, the unit can be lowered to the water, floated to a new work location, then raised again on electrically-powered legs—all within a period of several hours.

Mobile Drilling Barge Added To Ocean Drilling and Exploration

The world's largest mobile drilling barge was opened for inspection last March at Alabama Dry Dock & Shipbuilding Company yards in Mobile, Ala.

The barge "Margaret" is the latest addition to Ocean Drilling and Exploration Company's offshore barge fleet which now totals four. The Margaret is completely equipped with equipment manufactured or furnished by Continental-Emsco Company.

Built by Alabama Dry Dock and Shipbuilding Company the barge has the following specifications:

Length—300 feet Width—200 feet
Height of Main Deck above bottom—93 feet
Operating water depth (maximum)—65 feet
Two lower hulls with each hull 60 feet wide, 300 feet long, and 12 feet deep. These hulls are separated by an 80 foot gap.
Ten stabilizing columns (five on each hull) 15 feet in diameter.

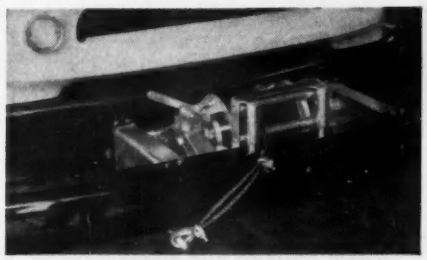
Bowen-Itco Appointed Gulf Oiltool Representative

D. M. Best, owner of Gulf Oiltool Co. of Houston, announced the appointment of Bowen-Itco, Ltd., P. O. Box 4123, Edmonton, Alberta, Canada, as executive Canadian sales representatives for their Gulf tubing tool joint.

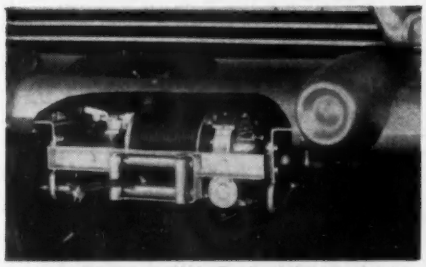
J. U. Kaye and Company To Represent Cleaver-Brooks

J. U. Kaye and Company has been appointed manufacturers' representative for the sale of Cleaver-Brooks boilers. The company is headed by Joseph Kaye, formerly sales engineer with the Machinery division of Dravo Corporation, Pittsburgh.

The territory served by the J. U. Kaye and Company includes western Pennsylvania, eastern Ohio, West Virginia and two counties in Maryland.



King Winch for S-120 4 x 4 International.*



King Winch on GMC Truck. Cut-away shows underslung mounting, featuring new hi-tensile strength design.

P.T.O.-Driven King Winch on Willys Jeep.

KING WINCHES

. . . for Willys Jeeps, 4 x 4 trucks and station wagons, International, GMC, Chevrolet, Ford, Land Rover and other vehicles.

COMPLETE, READY-TO-INSTALL FRONT-MOUNT WINCH ASSEMBLIES FEATURE:

- winch side arms to reinforce truck frame
- bronze-bushed, 4-way cable guide rollers
- cable drum guard
- heavy-duty pipe bumper
- needle-bearing, universal-joint spline-shaft drive assembly
- Timken bearings on worm

King Winches keep you moving through the most difficult terrain . . . you get action where there's no traction with dependable pulling power. King power winches have pulling capacities of 8,000 to 19,000 lbs.

*King Winches for International Harvester trucks are available through International distributors and dealers.

KOENIG ALL-STEEL CABS HAVE THESE SUPERIOR FEATURES:

★ Protection ★ Safety
★ Comfort ★ Convenience

Roll-down windows, full opening . . . full panel-board head lining and masonite door lining . . . safety glass throughout . . . all-steel welded construction . . . door locks.

Koenig ALL-STEEL CABS FOR JEEPS

FULL AND HALF CABS

Full Cab and Model 151J King Winch Illustrated.

Koenig

Koenig Jeep cabs and King Winches for Willys vehicles are available through Willys Motors, Inc., and Willys-Overland Export Corp. distributors or dealers. Write for free descriptive literature.

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West 12th at Ella Blvd. • Houston, Texas

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CLASSIFIED ADVERTISING

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Oil Field Drilling Engines
$4,500.00 each
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Made according to your specifications. Immediate delivery. Standard sizes of core bits and valves.
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Petroleum Engineer with Master's Degree, or Doctor's in Chemical, Mechanical, or Petroleum Engineering, for research and teaching in Petroleum Production Engineering at rapidly growing Southwestern institution. Rank and salary open, twelve months employment possible, consulting work encouraged and available in immediate area. Applications will be kept confidential. Box No. 124-W, WORLD OIL, Houston, Texas.

Graduate Petroleum Engineers needed to fill permanent position on Petroleum Engineering Faculty at Southwestern Louisiana Institute in Lafayette, Louisiana. M. S. or Phd. preferred, but will consider candidate for these degrees. Salary & rank depend on education and experience. Write G. G. Varvaro, Head Department of Petroleum Engineering, S. L. I. Lafayette, Louisiana.

MINIATURE
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All applications and data submitted will be kept in strict confidence.

HELP WANTED

■ MEN with experience as computers or observers in seismic or gravity work required by English company of Geophysicists. Write: Geophysicists, c/o WORLD OIL, 122 Moorgate, London E. C. 2, England.

BUSINESS SERVICE

■ **Delaware Corporations formed and serviced. Inquire without obligation. American Guaranty & Trust Company, 910 West Street, Wilmington, Delaware.**

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We are an Employer's service created to aid industry throughout the country in securing highly qualified personnel. We have many excellent applicants available in all branches of **engineering** and other **technical fields.** Many are willing to relocate and others desire foreign employment.
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IF YOU DESIRE TO PARTICIPATE IN OIL AND GAS PRODUCTION AND DRILLING DEALS THAT HAVE BEEN EVALUATED AND CHECKED BY RELIABLE SOURCES FOR GEOLOGY AND RESERVES, WE OFFER FROM 1/32 to ¼ UNDIVIDED INTERESTS WITH TAX ADVANTAGES ON CASH AND INTEREST DRILLING CONTRACTS, OR FARMOUTS THAT HAVE MORE INTEREST THAN CASH. WE TAKE CARE OF ALL PHASES FROM SECURING LEASE TO PRODUCTION IN TANKS AND MARKETING. YOU RECEIVE PAYMENT DIRECT FROM PURCHASING COMPANIES. WE EACH HAVE OVER 30 YEARS OIL FIELD EXPERIENCE.

WE ARE ADVERTISING FOR ASSOCIATES TO CHECK OVER DEALS AS THEY BECOME AVAILABLE IN THE ARKANSAS-TEXAS-LOUISIANA AREA WHERE WE ARE NOW OPERATING.

WRITE FOR REFERENCE LETTERS.

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RARE BUSINESS CONNECTION: My degree, experience, & background would be of considerable interest alone, but I'd also like to buy up to 50,000 common shares of aggressive, solid corp. & open division offices for you in Texas. Please write Ralph Hopkins, 8150 Dyer, El Paso, Texas.

Well organized, well established oil-well drilling contractor desires the management and supervision of oil properties in West Texas, Central Texas, and New Mexico. Can provide complete handling of oil properties from acquisition to production. No properties too small, and none too large to handle. Inquiries from independents, groups, small or medium sized oil companies invited. Write, wire or call collect for further information.
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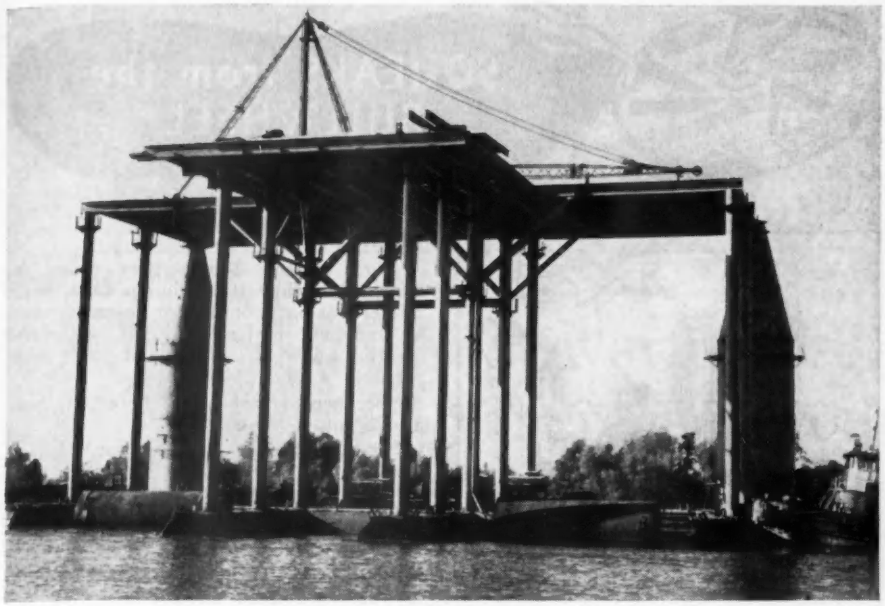

Kermac 46's Twin

U. S. Steel Bridge Division Builds Kermac 46 Twin

U. S. Steel's American Bridge Division dispatched a pair of steel structures which soon will be a model of the largest offshore drilling barge yet built. They are sections of Kerr-McGee Oil Industries' Kermac 47, a duplicate of the Kermac 46, which was commissioned last October at Pascagoula, Miss.

Principle behind the barge, which was designed by Kerr-McGee, is a grid pattern of big tubes forming the lower hull and four huge hollow corner members. The lower hull members are 14 feet in diameter, big enough to drive a truck through, the corner supports nearly big enough to run a two-lane highway through. The larger vertical tubes lend stability during raising and lowering. The horizontal tubes provide buoyancy as the unit is towed to location. There they are flooded, and with full equipment, over 8000 tons of steel settles the barge firmly to the ocean floor. It can operate in water up to 70 feet deep.

The assembled structure will measure 242 feet long, 202 feet wide and 100 feet high. When equipped, the barge and drilling mast will extend over 250 feet above the ocean floor. The corner supports are 22 feet in diameter for the lower 65 feet, tapering to 5½ feet at the deck.

To get the big structure from the plant down coastal waterways designed for conventional river craft, the barge was broken down into sections that would clear the channels, moved to the coast, then put together.

Kerr-McGee said the new barge is under contract to a major oil and gas producer.

FMC Acquires Major Majority Of Oil Center Tool's Shares

Food Machinery and Chemical Corporation's acquisition of over 98 percent of the 90,000 outstanding shares of Oil Center Tool Company of Houston was announced jointly by FMC executive vice president Ben C. Carter and OCT president John F. Maher. The transaction was completed by a share for share exchange of FMC common stock for the outstanding shares of Oil Center Tool.

Oil Center Tool Company, incorporated in 1929, is a producer of wellhead equipment to control flowing oil and gas wells. The highly complicated many-armed wellhead assemblies are the leading product line of the company. Both casing and tubing heads, the basic wellhead fittings from which the well casing and production tubing is suspended, and upon which the christmas tree is mounted, are also included among OCT's principal products.

FMC officials say the new acquision is a result of the company's planned expansion in the petroleum equipment industry. FMC products such as pumps, wing unions, swivel joints and a variety of specialty items are rapidly becoming a principal product area of the company's machinery operations. The addition of OCT product lines will help round-out FMC's current activities in the design and production of diversified petroleum equipment.

Oil Center Tool Company will function as an FMC subsidiary operation with no changes in management contemplated.

MISCELLANEOUS

VENEZUELAN OIL SCOUTING AGENCY

Periodic operations reports (industry-wide)—Maps—Newsletter

Cables: VOSA, Caracas, N. R. VanMiddlesworth Airmail: Apartado 3963 Phone: 54 48 02

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480 ACRES in Coleman County, Texas. 190 acres in cultivation, 5 producing oil wells. 120 not leased in Novice field. Will sell land and mineral rights to settle Estate. Contact Sam Sprinkles, Novice, Texas, Box 37.

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35,273 acre cattle ranch in North Central Montana between Helena and Great Falls, of which 31,240 acres are patented and 4,034 acres leased state land. The entire ranch is admirably located as to modern highways and railroad service.

A beautiful ranch in beautiful country noted for its high quality grasses. The entire ranch is exceptionally well watered with rivers, creeks, and numerous springs. In this exceptionally dry year, no pasture was idle for lack of water.

Modern irrigation system recently overhauled and protected by ample water rights.

Well fenced, good buildings, modern machine shop, excellent corrals, scales and everything required for first class cattle operations.

Three modern dwellings served by natural gas and commercial power, daily mail, school bus and telephone.

Hay production 1,100 to 1,600 tons and developments now under way will further increase hay production. Capacity 2,400 animal units without over grazing. An excellently balanced ranch, now in full operation.

Property will be priced per acre of deeded land which would include all water rights and improvements, with the understanding that all leases will be assigned if the deeded land is purchased.

Machinery, equipment and livestock will be separate negotiations.

All but 2% of the oil and mineral rights are reserved to the sellers.

IF INTERESTED COMMUNICATE WITH—

EDWIN N. HARDY

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Built for Men Who Know

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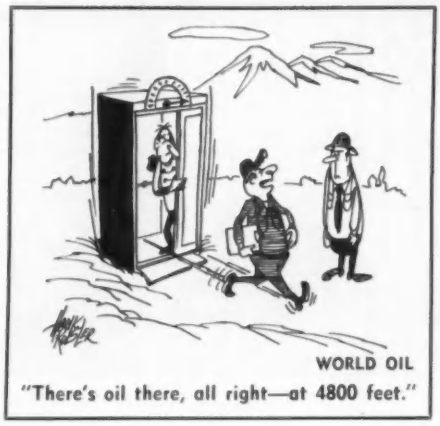

WORLD OIL

"There's oil there, all right—at 4800 feet."

It Makes a Difference!

Rich aunt: "I'm sorry you don't like your gift, but I did ask you if you wanted a large or small check."

Nephew: "Yes, but I didn't know you were talking about neckties."

Caught!

Smith handed his pay check to his wife every Friday. She gave him back $4 a week for spending money.

One evening he came home trembling with excitement.

"Sally," he cried, "Guess what! We've won fifty thousand dollars in a lottery. Just think, fifty thousand!"

Sally paused from her work and replied in icy tones, "And where did you get the money for the ticket?"

Mistaken Identity

Two Englishmen out on the town for the night picked up two girls and took them to a dimly lighted pub for a beer. Suddenly one turned to his friend and whispered, "I say, old boy, would you mind terribly changing dates? Between the grog, the fog and the smog, I seem to have picked up an old aunt of mine."

Horticulture

In the language of flowers, the yellow rose means friendship, the red rose means love and the orchid means business.

Really Gone!

Again the young wife called her parents to report that her husband had left home after a quarrel.

"What of it," the father retorted, "he's done it before and he's always come back."

"But this time he took his golf clubs," the daughter wailed.

Appreciation

She had a friend up in the hills of Kentucky. When the friend wrote to tell her of the arrival of her third child, she ordered a child's playpen and had it sent. In about a month, the friend sent back a note of thanks. "Thank you so much for the pen. I sit in it every afternoon and read—and the children can't get near me. It's wonderful."

No Rush

Over in the Bronx, they grow 'em tough, and they start young. One truant officer was out scouting for absentees when he suddenly noticed a small boy seated on the curbing at a particularly busy corner.

"See here, young man," he asked, "why aren't you in school?"

"Hell fire!" growled the tot, "I ain't but five damn years old!"

Broadminded

A small boy lost himself at the auto show. He was crying loudly when a policeman found him and asked him what was the matter.

"I'm lost," said Charley.

"Oh," said the policeman, "who were you with?"

"My father," said the lost child.

"And what's your father like?" the officer asked.

"Beer and women," sobbed Charley.

Gluttony

Some years ago, a drilling crew had been working in a Scurry County location for days, subsisting on nothing but salt pork and hardtack.

Finally the men decided they needed a change of fare, so they sent one of their number on the long trip to town for a new supply of food. Eventually he returned—with 12 quarts of whisky and one medium-sized loaf of bread.

As one man, the crew cried: "Now what the hell are we going to do with all that bread?"

Good Alibi

Little Johnnie, being reprimanded by his teacher for being tardy for school, remonstrated with the following excuse:

"Ma woke Pa up in the middle of the night saying she heard something in the hen house. Pa, who sleeps in the raw, grabbed his loaded shotgun and ran out into the yard. Pa stood there, with his gun pointing at the chicken house, waiting for something to come out when our old hound dog came up behind Pa with his cold nose . . . and we've been cleanin' chickens since three o'clock this morning."

Psychic

Owner of a large furniture store was in Chicago to attend the Mart. While going up on the hotel elevator he met a beautiful girl who gave him a friendly smile. This furniture-store executive tried to become acquainted, but quickly discovered the girl was French and that they couldn't understand a word of each other's language.

So he drew a picture of a taxi and she nodded her head in agreement and went for a ride in a taxi. While riding he drew a picture of a table in a restaurant and again she nodded in agreement, so they

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Service *Anywhere Anytime*

New Services • • • New Tools • • • New Methods • • • Outstanding Results

Powerful M-3 Guns Increase Production 316%

Hard Shooting M-3 Guns, Firing Improved Ogival Bullets, Gain 38 B/D Over Previous Jet Perforating

An excellent example of the penetrating power of McCullough M-3 Bullet Guns was recently reported from a California oilfield.

This was a shallow, low production field. The well had previously been perforated by another service company with shaped charges for a settled production of 12 barrels of oil per day.

Productive interval lay between 3837′ and 3872′ and was cased with special 7″ O.D. 51 lb. casing. Casing was cemented in 9¾″ hole through the pay zone.

Although skeptical of the ability of any bullet perforator to gain effective penetration through the extra heavy casing and thick cement sheath, the operator called for McCullough M-3 Bullet Guns.

McCullough Service Crew made three runs with 4¾″ O.D., 20-shot M-3 Guns, firing 140 improved ½″ Ogival Bullets, four per foot, in the 35′ zone.

Production increased from 12 to a settled 50 barrels of oil per day—a gain of 38 barrels. The job required two hours, including rigging up and tearing down. To quote the operator, "Results were very satisfactory and gratifying".

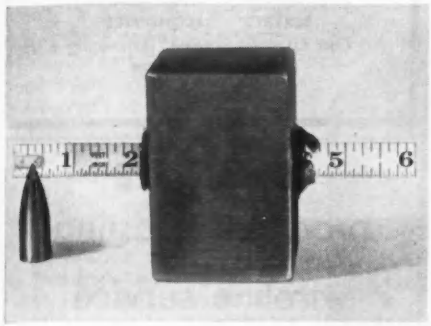

Illustration above shows a 2½″ steel test sample pierced by an improved ½″ Ogival Bullet fired by a McCullough M-3 Bullet Perforator.

McCullough Sectional Gun Gains Penetration Where Previous Attempt Failed

Depth of operation was only 1487′. 4½″ O.D. casing had been cemented in 10¾″ hole. Pay zone was bullet perforated by another service company but the formation would not break down. During the attempt to fracture, the pipe split above the zone and collapsed in the perforations.

Operator swaged out the 4½″ casing, ran a 3″ liner inside the 4½″ and cemented the annulus. This operation made an impressive amount of steel and cement to be penetrated to gain production.

McCullough shot 20 improved ⅜″ Ogival Bullets in the zone and the formation broke down at 800 lbs. Time on the job was one hour. Results: a good well and a satisfied oil man.

McCullough Sectional Guns are available in 1⅛″ O.D., 1¾″ O.D. and 2¼″ O.D. sizes.

"world's hardest shooting bullet perforator".

M-3 Penetrates Two Strings For a Good Well

Two strings of casing had been set through the pay zone at 5587′–5590′. 5″ O.D. 18 lb. liner was cemented in 7⅝″ O.D. 28 lb. casing which, in turn, was cemented in 11¼″ open hole.

A 3½″ O.D. McCullough M-3 Gun fired 18 improved ½″ Ogival Bullets in the three foot pay zone. Operator stated he is satisfied it is his best completion to date.

Burr-Free Penetration

A new Burrless Bullet Cap, if desired, is inserted over the point of the improved Ogival Bullet at the time the M-3 Gun is loaded. It provides a completely burr-free hole on the inside surface of the perforated casing. Symmetrical, smooth holes make the use of ball sealers more effective in acidizing and sand fracturing—assuring more complete perforation shut-off.

Burr-free holes make casing scraping only a routine, precautionary measure and insure free passage of swabs, packers or other close fitting tools.

The jobs described above are certified to be true and accurate field reports of services rendered.

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Stitt "X" Type Sour Gas plugs resist corrosive action of sour gas — last months longer — require fewer changes — cut "down" time. It's not the plug price, but the "change cost" that's important! Stitts cost a little more — save hundreds of dollars per engine per year. Factory equipment in Clark, Cooper-Bessemer, Worthington, other leading engines.

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CLEAN OUT CHOKING SAND

Excessive sand and sediment holds back your oil. For fast, easy clean out with fewer round trips and less down-time, use world famous Miller Sand Pumps.

SAND PUMP SIZES
O.D.—2½, 3, 3½, 4¼, 5, 5½, 7 In.
Lengths—20, 25, 30 ft.

Composite Catalog, Page 3369

Write for descriptive price list

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Miller Sand Pump Co.
General Offices, Box 4516
Oklahoma City 9, Okla.

EXPORT OFFICES
30 Rockefeller Plaza
NEW YORK CITY 20, N. Y.

went to a fine restaurant for dinner. After dinner he sketched two dancers and she was delighted. They went to a nightclub and had a lovely time.

Then the girl indicated that she would like to use the pencil and paper which he gave her. She drew a picture of a four-poster bed.

He was dumbfounded. He's never yet been able to figure out how she knew he was in the furniture business.

Speed of Flight

New planes are getting so fast you don't have time to get acquainted with the stewardess anymore.

Ultra Modern

"I feel awful. I ache all over."

"What's the trouble?"

"My wife bought a lot of ultra modern furniture, and I just found out that all this time I've been sleeping in the bookcase."

New Approach

A clergyman who ended his conversations with an invitation to come to church ate in a restaurant one evening where he was waited upon by a dizzy blonde.

He gave her a pleasant smile as he arose to leave and said, "That was a very good meal. Good evening and I hope I'll see you in Sunday school."

With hands on hips, the blonde stopped snapping her gum and replied, "Say, brother, I don't know what your pitch is, but your approach sure is different."

Unnecessary Feature

Then there's the story about the mountaineer who brought his bride to the new cabin he had built.

"Wal gal, how do you like it," inquired the bridegroom.

"Ain't bad, but there's no door," replied the blushing bride.

"Wuz you figuring on goin' some place?" asked the bridegroom.

Even the Boss

Executive: "Your reports should be written in such a manner that even the most ignorant may understand them."

Office Boy: "Well, sir, what part is it that you don't understand?"

Good References

The potential new cook came to be interviewed. "Do you have references?" asked the lady of the house.

"Not exactly," admitted Augusta, and dug into her apron pocket, only to display a set of silver spoons, each with a different family coat of arms or crest. "But look for yourself: I've worked only in the very best of families."

Higher Math

The teacher was trying to give her class an impression of fractions. She told them they could think of fractions at home as well as in school and gave such examples as "half a sandwich," "a quarter of a pie," and "tenth part of a dollar."

At that point one little boy caught on and proudly contributed, "My father came home last night with a fifth."

Dumb Animal

After weeks of painstaking effort, a hunter taught his retrieving dog to bring back ducks by walking upon the surface of the water rather than swimming out after them, says *Legion* magazine. He

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New

Sol-Treet makes paraffin problems a thing of the past!

As you know, I had tried everything to dissolve my down-hole paraffin, with no results. The well was making from 3 to 5 barrels a day. As a result of your Sol-Treet the tubing and flowlines are free of paraffin and the well is now making 30 barrels a day.

Sincerely,
Tom Pappas

Tom H. Pappas
Co-owner and
Production Supt.
Paco Petroleum Corp.
Mt. Carmel, Illinois

The above excerpt from an unsolicited letter is a typical Sol-Treet success story. Sol-Treet has been field-proven effective in stopping paraffin problems. Excellent results are being obtained in use in pumping and flowing wells, recycling, lead lines, and breaking out and dissolving BS and paraffin in tank bottoms. Available at most supply stores, or contact

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"Chemicals for the Oil Industry"

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with automatic digital readout

TRACERLAB RLP-6
50-CHANNEL SCANNING SPECTROMETER SYSTEM,
here shown with optional Ratemeter.

Complete system for assaying radioactive samples quantitatively on continuous or stepwise basis consists of:

- **Precision high voltage power supply**
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- **Linear amplifier**
- **Preset count and preset time scaler**
- **Automatic digital readout**
- **Building block design principle for easy tie-in with other Tracerlab equipment.**

The accuracy of digital readout, heretofore available only in multi-channel analyzers, may be obtained from the Tracerlab RLP-6 50-Channel Scanning Spectrometer System at a cost comparable to the conventional single channel spectrometer system with ratemeter-recorder. It can be used with an automatic sample changer.

For complete information, write for Tracerlog No. 78.

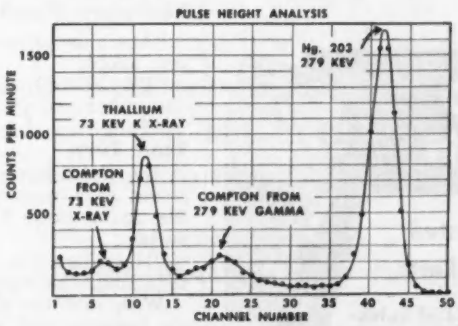

CHART OF SPECTRUM OBTAINED FROM Hg 203 shows plot of data from sheet pictured below.

DATA FROM AUTOMATIC READOUT TYPEWRITER includes channel number, count, time in minutes, time of day.

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Heat-proof, vibration-proof, non-solvent, non-shrinking, non-crumbling, non-cracking . . . for every gasketing and sealing requirement. Makes all assemblies leak-proof and pressure-tight. Withstands heat or cold, high pressures, oils, gases. Prevents rust, corrosion, and seizure of joints.

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A powerful blend of quick-acting, super-penetrating solvents. Frees parts frozen by rust, corrosion, scale, paint, varnish, carbon or gum.

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Dept. 1

CHARLOTTE, NORTH CAROLINA

2161

"I tell him why he will never make a driller; he writes it up and sells it to a magazine for $40."

wished to show off this wonder dog to a friend, so without a word about it they went hunting together. And when the owner shot his first duck, he sent the dog out after it. The dog walked lightly upon the water, retrieved the duck, and walked back to deposit the bird at his master's feet.

"Notice anything?" asked the master expectantly.

"Sure," answered the friend. "That crazy dog of yours can't swim!"

Power of Suggestion

The minister was telling his congregation that they should not frequent bars and night clubs. Just then a man in the second pew jumped to his feet, attracting much attention. As the parishioners were leaving the church at the end of the services, the minister stopped the man.

"What was the reason for the commotion during my sermon?" he asked.

"Well, you see, Reverend," explained the man, "when you mentioned bars and night clubs, I remembered where I left my umbrella."

Perfectly Matched

"Are they a well-mated couple?" the wife asked.

"I'll say they are," replied the husband, "he snores and she is deaf."

Your Turn

The drunk sitting at the bar was adjacent to a man and his wife. Suddenly the drunk came forth with a resounding burp.

"How dare you belch before my wife," thundered the husband.

With that the drunk unsteadily got off the bar stool and, making a sweeping bow, replied: "A thousand pardons. I did not know it was the madam's turn."

That's Enough!

The foreman and his bride were honeymooning and decided to try boating. They drifted out too far and were caught by a current that carried their boat beyond the sight of land. The foreman started to pray:

"O Master, if you will wash us back to shore I'll quit smoking, gambling, drinking—"

"Don't go too far, Honey," shouted his bride. "I think I see a sail."

Same Game

"Did you ever play football?" asked the Yale graduate of a visiting Englishman.

"No, sir, but at dear old Oxford we played rugby."

"How is that played?"

"Well, sir, it consists of a lot of shin kicking."

"In this country we call that bridge."

A Fine Fix!

A young soldier called on a 16-year-old girl, and remarked to her parents that he was from Philadelphia.

The girl's father commented that he and his wife were married there 17 years ago. A startled expression passed over the soldier's face.

Next morning the daughter said in disgust. "That certainly did it, Father. I had told him I was 18; so then of course, I had to tell him I was illegitimate."

Just Right

"Mary," admonished the mother who objected to her daughter's tomboyish antics, "don't you think you are getting too big to play with boys?"

"Oh, no Mother!" exclaimed the daughter frankly. "The bigger I get the better I like 'em!"

Anywhere, U.S.A.

A Texas tycoon rushed into the airport terminal and said, "Gimme a ticket."

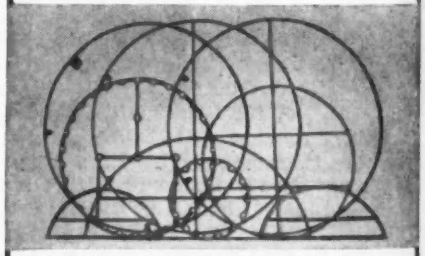
"Where to, sir?" asked the agent.

"Anywhere, son!" boomed the Texan. "I've got business all over."

Chick's Lament

A lonely chick taking a look around the electric incubator of unhatched eggs—"Well, it looks as if I'll be an only child. Mother's blown a fuse."

Need GASKETS for HEAT EXCHANGERS?



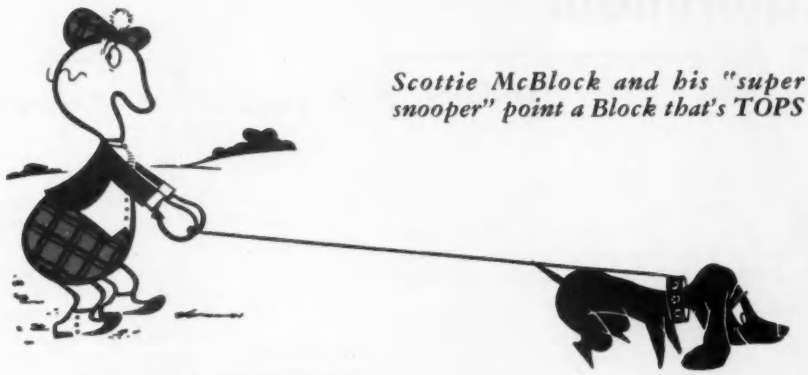
Call CHICAGO-WILCOX for PROMPT DELIVERY

Here is a dependable source for gaskets for heat exchangers. These gaskets can be made in any size or shape as needed—cut from solid metal, sheet-packing; also double jacket type.

Send specifications, blue prints or templates, for quotation and a prompt-delivery schedule for normal stocking orders.

CHICAGO-WILCOX MFG. CO.

7709 Avalon Avenue, Chicago 19, Ill.
Phone: SAginaw 1-1900



Scottie McBlock and his "super snooper" point a Block that's TOPS

McKISSICK'S *STREAMLINED* TUBING BLOCK

Here's the block with the very widest range of sizes and capacities. For most efficient, trouble free handling of tubing, rods, etc.

Featuring E-Z opening guards, an exclusive McKissick feature, for quick, simple reeving, a few turns, bolts swing out. No parts removed — guards swing on extended arm to closed position and lock bolts tightened.

McKISSICK builds a "Better Block for Every Purpose"

Write for complete catalog

McKISSICK

McKISSICK PRODUCTS CORPORATION

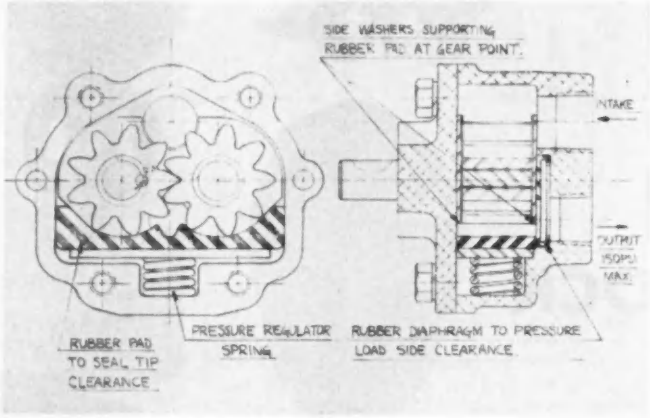
Box 2496 Tulsa, Oklahoma

What's New In Equipment

Drilling • Production • Exploration

Simple Gear Pump

A new gear pump, featuring simplicity of design that lends itself to low cost manufacturing techniques has been developed by New Products Corporation. Suitable for fluid pressure up to 200 psi, this new pump can be readily adapted for a multiplicity of applications, including engine oil pumps, primary pump for fuel injection systems, pumps for automatic transmissions, pumps for oil burners, pumps for low pressure machine tool mechanism and pumps for manufacturing equipment of all kinds.


SIDE WASHERS SUPPORTING RUBBER PAD AT GEAR POINT
INTAKE
OUTPUT 150PSI MAX.
RUBBER PAD TO SEAL TIP CLEARANCE
PRESSURE REGULATOR SPRING
RUBBER DIAPHRAGM TO PRESSURE LOAD SIDE CLEARANCE

The typical arrangement for a basic version of the New Products Corporation pump, as illustrated, shows the two conventional gears mounted on shafts in a simple housing which can be designed to suit the specific application. Unique feature of the design which sets it apart from the conventional is found in the fact that the mating gears can be mass produced without the penalty of close tolerances or fine tooth finish. They can be hobbed or rolled or made of metal powder and used without fussy finishing operations.

Similarly the housing cavity can be used practically as die-cast without machining or profiling around the periphery due to the fact that peripheral clearance plays no part in the performance of the pump.

Secret of the unique performance of the New Products Corporation pump stems from three basic elements that constitute the heart of the invention. First, is the molded synthetic rubber element which conforms with zero clearance to the gear teeth along the pressure outlet side of the pump. This is the only area that requires close clearance and at this point it is perfectly feasible to achieve zero clearance without resorting to fine mechanical tolerances. In conventional pumps close tolerance fits are required about the entire periphery to obtain reasonable characteristics. Yet peak efficiency still is unattainable because zero clearance is difficult and too costly from a manufacturing standpoint. Moreover, it could not be maintained in service because of erosion due to metal-to-metal contact.

To provide for complete safety of operation, a calibrated spring is installed as shown to control the action of the tip clearance pad. In effect, it serves as a pressure relief valve, so calibrated as to cut off at an established maximum pressure value, thereby permitting the tip clearance pad to retract from its contact with the gears.

The third feature is the molded synthetic rubber diaphragm installed under the two gears. Its use permits a reasonable degree of back-lash in the mounting of gears within the housing, again contributing to low cost machining practice. In operation, the diaphragm is automatically inflated by pressure fluid, thereby taking up all clearance between the upper and lower faces of the gears.

For more data, circle **No. E1** on Readers' Service Card, last page this issue.

Forward Control Jeep

A new four-wheel drive truck, the Forward Control Jeep FC-150 is being introduced by Willys Motors, Inc., as an addition to the company's expanding line of four-wheel drive Jeep utility vehicles. The FC-150 embodies new design and engineering features which have been combined to provide a vehicle with maximum cargo space in relation to wheelbase.

Key to the over-all engineering advances in the new vehicle is the up-front location of the cab, situated well forward of the engine. This forward control design allows maximum usage of the vehicle's compact 81-inch wheelbase for payloads, and places the driver in the optimum position for all-direction visibility and vehicle control.

Powered by the Willys F-head Hurricane engine, the same power plant proved for ruggedness and economy in both military and civilian models of the Jeep, the FC-150 is engineered with four-wheel drive for off-the-road service over all types of terrain. For normal highway operation, the vehicle shifts easily into conventional two-wheel drive.

The FC-150 offers nine forward and three reverse power combinations. The change from conventional to four-wheel drive is readily made by shifting the single floor-mounted transfer case control lever to meet varying driving requirements without stopping the vehicle.

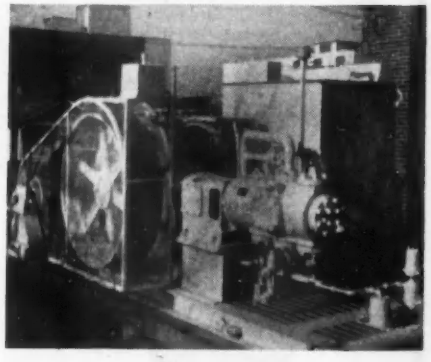
An optional four-speed transmission, available at extra cost, provides 12 forward power combinations.

Forward control design provides a payload bed more than six feet in length despite the vehicle's highly maneuverable 81-inch wheelbase. With tailgate extended, cargo length is 92 inches.

With a ground-hugging low center of gravity, the payload bed is only 24 inches from the ground, most convenient loading height of any four-wheel drive vehicle.

A large, roomy interior is a feature of the safety-view cab, which provides up-front visibility 200 percent greater than in conventional vehicles. The high, wide wrap-around windshield is almost 1200 square inches in area, and the driver can see an object on the road as close as six feet from the front bumper.

For more data, circle **No. E2** on Readers' Service Card, last page this issue.

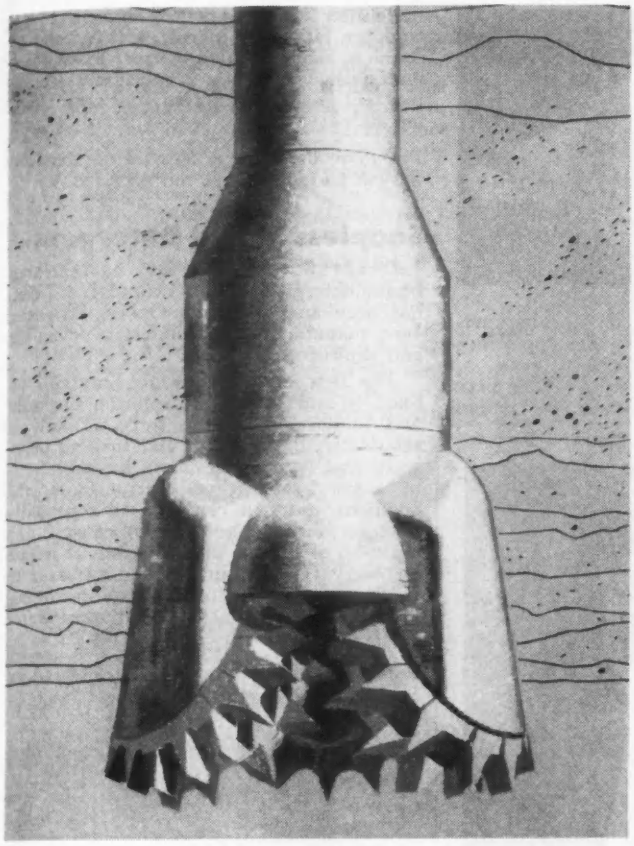


Packaged Gas Compressor

Southern Engine & Jump Company had the showing of their new packaged gas compressor units on recently at their plant in Houston. These Southern packaged units, using LeRoi Engines and Worthington Compressors, are custom designed, engineered and assembled in Southern Engine's Houston shops.

More working area is given the service man by placing the horizontal separator and most of the piping within the base. For safety and cleanliness flush-mounted grating is used for decking. The engines range from 50 horsepower to 600 hp maximum; compressors have either 9-inch, 11-inch or 13-inch strokes with various cylinder sizes. Units may be furnished with a central cooler for engine cooling, gas inter and after cooling and compressor cooling.

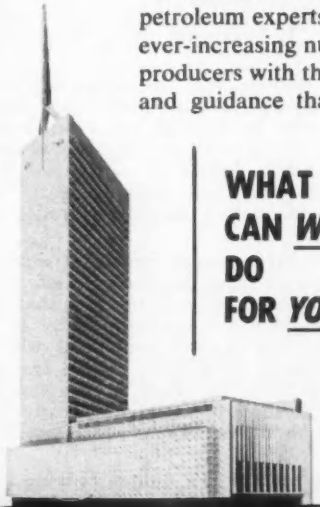
For more data, circle **No. E3** on Readers' Service Card, last page this issue.



LET'S GET TO THE BOTTOM
of your financing problem

The quickest, most profitable way to solve any oil production financing problem is to bring it directly to the Oil Department of Republic National Bank of Dallas. Here is a pioneer oil bank of the Southwest . . . the South's largest staff of petroleum experts, serving an ever-increasing number of producers with the kind of counsel and guidance that always asks first . . .

WHAT CAN *WE* DO FOR *YOU?*



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MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

CAPITAL AND SURPLUS $75,000,000 LARGEST IN THE SOUTH

As *SIMPLE* and Dependable as the Pull of a MAGNET!

A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol.

MAGNETROL

The Simplest, Most Versatile LIQUID LEVEL CONTROL Ever Devised!

Linked to liquid level by infallible magnetic force, Magnetrol is free from the limitations inherent in mechanical or electrical controls. With the actuating magnet rated at 98% of initial strength after 30 years, Magnetrol has *infinite operating life,* with practically no maintenance at all. There are no wearing parts to get out of order.

What's more, Magnetrol's simple operating principle permits easy, economical modification of standard units to meet *any* pressure, temperature or corrosion requirements. That's why there's practically no limit to Magnetrol's use. It's also why "specials" are likely to be standard with us. Magnetrol units control level changes from .0025-in. to 150-ft. —with single or multi-stage switching.

MAGNETROL, Inc.

● *SEND COUPON FOR DETAILS*

MAGNETROL, Inc. 2114 S. Marshall Blvd., Chicago 23, Illinois
Please send me catalog data and full information on Magnetrol Liquid Level Controls.
Name_____
Company_____
Address_____
City_____ Zone_____ State_____

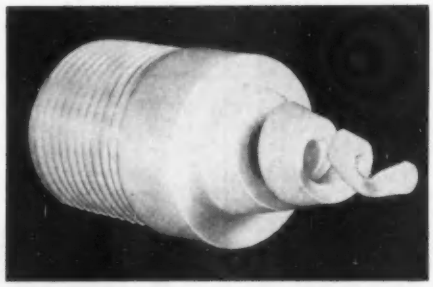
For more data on advertised products, use Readers' Service Cards, last page.

Teflon Full Cone Nozzles

Fourteen new models of spiral nozzles of Teflon have been added to its line, according to the Bete Fog Nozzle, Inc., of Greenfield, Mass. It is now possible to obtain full cone spray patterns, both wide angle (120 degrees) and narrow angle (90 degrees), in addition to the hollow cone models formerly manufactured by this company. A wider range of flow rates is also available.

The complete line, called the TF series, now includes nozzles with orifices from ⅛-inch diameter to ½-inch diameter and with flow rates from 2 to 70 G.P.M.

The Bete spiral design atomizes the fluid without the necessity for vanes or internal parts. The manufacturer claims



better atomization and non-clogging performance. Particles smaller than the orifice pass freely through the nozzle.

Each nozzle is made from a single piece of Teflon. Because of the simple design these new nozzles are not expensive but compare favorably in cost with nozzles of stainless steel or other corrosion resistant materials. The Teflon is unusually erosion resistant and will often outwear hard metals.

For more data, circle **No. E4** on Readers' Service Card, last page this issue.

Soapless Liquid Detergent

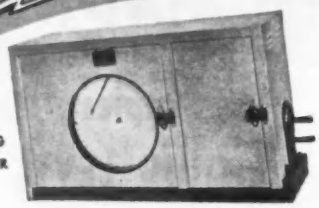
Development of a new concentrated liquid detergent, called Oakite Liqui-Det, has been announced by Oakite Products, Inc., manufacturers of industrial cleaning and sanitizing materials.

The new detergent, which contains no soap, is said to go into solution instantly and to develop copious suds, in hard or soft water, hot or cold, and then to penetrate and loosen the most common soils in a very short time. Furthermore, the company states, it can be used repeatedly without rinsing, and without causing any build-up of film or discoloration. It is safe on every type of surface and pleasant to the hands. As for economy, concentrations as low as ¼ ounce to the gallon of water are being used with excellent results.

For more data, circle **No. E5** on Readers' Service Card, last page this issue.

ARCCO

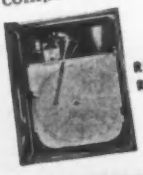
NOW SPECIFIC GRAVITY RECORDING OF LIQUIDS AT ANY DISTANCE



RECORDING TRANSMITTER

Accurate long-distance transmission of specific gravity recordings is no longer a problem with any of the new RMT Models of Arcco-Anubis Recording Gravitometers for recording and transmitting liquid gravity records. These instruments combine the mechanism of the standard Arcco Liquid Gravitometer with a metameter telemeter transmission system which records and transmits the specific gravity record to control room or other remote location. The interconnecting line may be any two-wire electrical circuit or its equivalent: private wires, telephone circuits, carrier current channels, or radio (VHF or UHF).

The range of the standard instrument is .15 or larger, but instruments with ranges of .10 or .05 can be supplied. Charts are available for more than 75 different ranges of Specific Gravity or Degree A.P.I. Special ranges can be furnished at slight additional cost. Request Bulletin No. 111-R3 for complete details.



RECORDING RECEIVER

AMERICAN RECORDING CHART CO.
3113 E. 11th St. • Los Angeles 23, Calif.

SEND FOR BULLETIN No. 111-R3

Rough Country Vehicle

A radically new type of vehicle for transporting freight over rough open country, without benefit of highways or railroads, has just been introduced by R. G. LeTourneau, Inc., of Longview, Texas.

So nimble are the new light-footed Transporters that the only roads they require may be through soft sand, powdery snow, deep mud or dense underbrush. Even when loaded to their full 35-ton capacity, the giant truck-like carriers can take wide gullies and steep grades easily in stride.

Probably the most important single factor contributing to the success of the super-heavy haulers is the fact that a DC electric motor is geared directly to each wheel—making each individual wheel an independent drive unit. Should one wheel lose traction, its share of the machine's total horsepower is automatically transferred to other wheels which are taking hold.

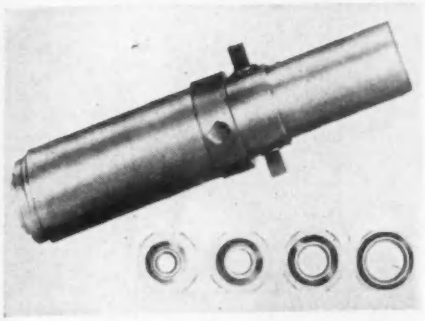
Also utilized is a unique braking system which actually has no parts to wear out or replace. This is made possible by a regenerative, or feeding back, action of the electric motors in the wheels. When machine travel-speed becomes greater than the driving speed of the motor, they begin acting as generators and, in effect, create power to stop themselves. Mechanical brakes, however, also are furnished on the

machine for use in making emergency stops, or when the vehicle is parked.

Another factor which contributes to the machines' successful rough-terrain operation is the use of large low-pressure tubeless tires which measure more than six feet tall and have treads 2½ feet wide. To assure ground contact of all six wheels at all times, and to dissipate road shocks, the Transporters have a flexible suspension system, utilizing an oscillating front axle and walking-beam rear axles.

Electric power for DC motors in the wheels, as well as for an AC motor used for steering, is provided by two LeTourneau-built generators driven by a 335 horsepower diesel engine. A single control completely governs speed, power and braking. To steer the giant vehicles, an operator merely pushes a finger switch to the left or right.

For more data, circle **No. E6** on Readers' Service Card, last page this issue.



Speed-Thru Nipple Chuck

Pipe nipples can be made quickly on the job with either hand threaders or power drives through the use of the new Speed-Thru nipple chuck just announced by Mercury Hydraulics, Inc., of Denver.

The manufacturers claim that the patented new chuck is the only tool on which nipples of any length can be made with all threaders that are adjustable to 2 inches. Due to a movable sleeve guide, there are no dead spots to prevent threading to any pre-determined length, fractional or otherwise.

Speed-Thru nipple chuck operation is described as requiring three steps. First, thread one end of any pipe, or pipe remnant of the desired diameter and cut to the required length. Second, clamp the nipple chuck in either a vise or power drive and screw the bald nipple into the holding bushing. Third, with threader guides opened to maximum, thread in the usual manner, then release the holding cam and the finished nipple will unscrew by hand.

The chuck is further described as precision machined with all wear parts made of hardened steel. During service tests, according to the manufacturer, one chuck was used to make over 2000 nipples of all sizes, without any wear defections.

Each nipple chuck comes packed in a heavy gage metal tool box with holding adapters from ½-inch to 1½-inch diameters. Two inch diameter nipples thread into the chuck body for holding. One-eighth-inch, ¼-inch and ⅜-inch adapter bushings are optional. Over-all length of the chuck is less than 10 inches. The chuck will also be available with adapters for British standard pipe thread.

For more data, circle **No. E7** on Readers' Service Card, last page this issue.

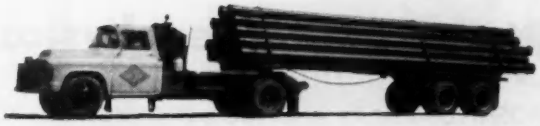
***Congrats and $25.00 to T. R. EMBACH, Pure Oil Company, Crystal Lake, Ill., for this quip.**

"..lookin' for a loggin' job"

World conditions call for more and more oil . . . and in turn, more and more Lone Star pipe . . . API casing, tubing and line pipe.

Our friend and neighbor, Joe Roughneck . . . heart of the oil and gas industry . . . knows our plant is operating day and night to supply his needs. He knows, too, that we're working on our new stretch-reducing mill and another open hearth furnace. Ultimately, these will mean more steel and more pipe.

Neighbor, wherever you are . . specify Lone Star and we both get a good deal!



Lone Star STEEL COMPANY

LSS

EXECUTIVE-SALES OFFICES
W. Mockingbird Lane at Roper • P. O. Box 12226 • Dallas, Texas

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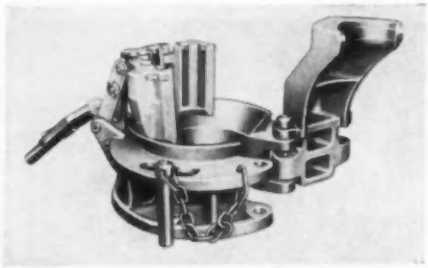
Houston, Texas | Midland, Texas | San Antonio, Texas
Tulsa, Oklahoma | Wichita Falls, Texas | Shreveport, La.

For more data on advertised products, use Readers' Service Cards, last page.

PRODUCTION

Automatic Tubing Spider

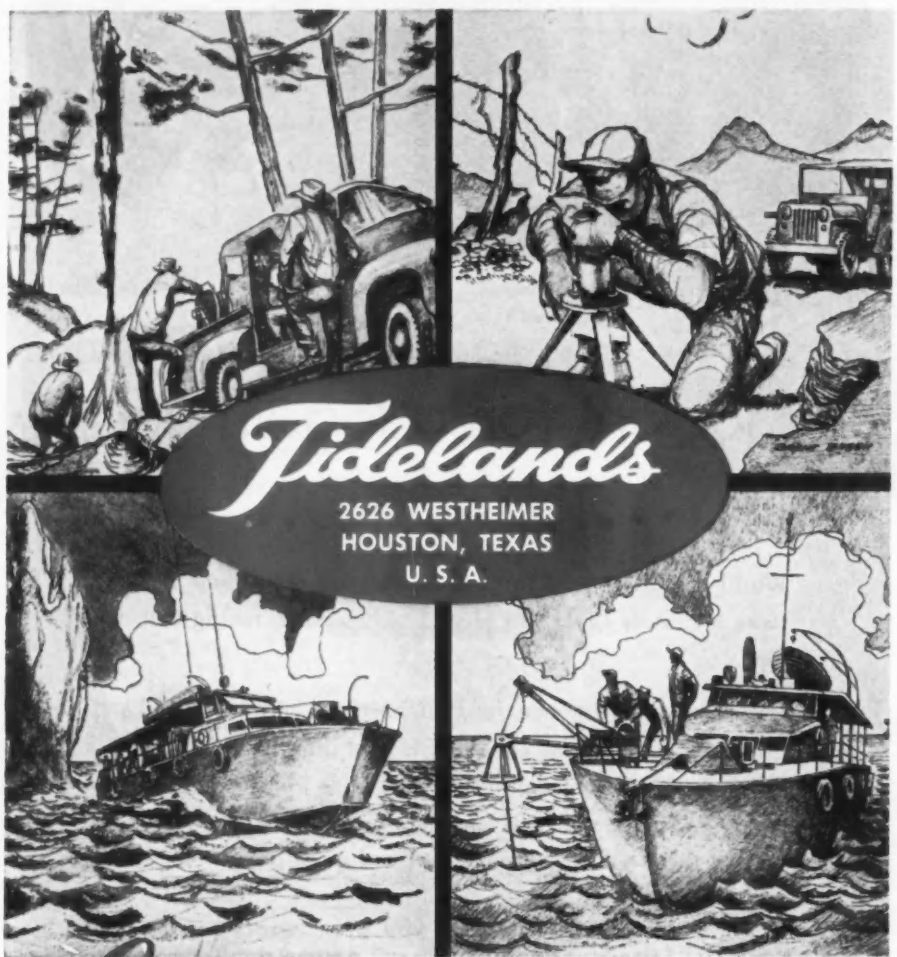
The Guiberson Corporation, one of the Dresser Industries, announces availability of their new Type H automatic tubing spider in 2-inch, 2½-inch or 3-inch tubing size. The Type H tubing spider is designed for medium or light duty. Twelve heat treated solid slip inserts fit exactly and take a firm grip on the tubing. Replacement inserts are economically priced and the full set may be replaced, for little if any more than the usual charge for resharpening conventional slips. The spider is easily gripped by convenient slots in the top flange and the complete unit may safely be handled by only one man.



Unless otherwise specified, the spider is furnished with a guard gate which protects the slips and linkage against accidental blows from the elevators. The built-in guard also serves to center the tubing in the spider bowl. Where lighter weight is essential, the spider is available at no extra cost with a plain gate. The slips, of three point contact design, give maximum support without crushing the tubing. Slips will support J55 tubing up to 9000 feet in 2⅜-inch O.D. 4.7 pounds, 8000 feet in 2⅞-inch O.D. 6.5 pounds, or 6000 feet in 3½-inch O.D. 9.3 pounds size. Slip inserts pivot and grip against rotation in either direction, eliminating need for backups. All parts are precision machined for complete interchangeability.

(This item supplements The Guiberson Corp. data on Pages 2081-2088 of the Composite Catalog, 21st Edition.)

For more data, circle **No. E8** on Readers' Service Card, last page this issue.



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FOR POSITIVE RESULTS AND HIGH PRODUCTION, YOU CAN DEPEND ON TIDELANDS' EXPERIENCED CREWS

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- Radioactivity surveys
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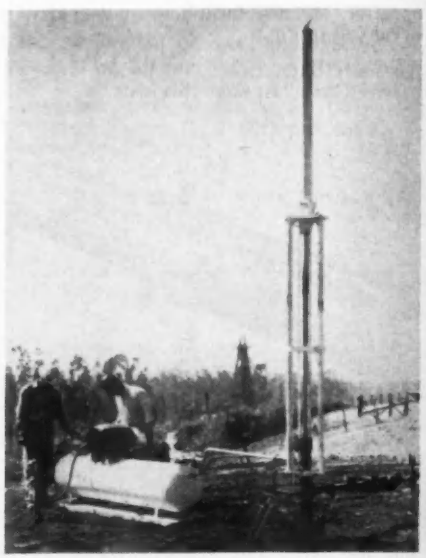
Tidelands

EXPLORATION CO. • GEOPHYSICAL CO., INC. • OFFSHORE, INC. • OVERSEAS, INC.



Hydrax Pumping Unit

A 4-foot Junior Hydrax pumping unit has been added to the hydraulic line of Axelson Manufacturing Company, Division of U. S. Industries, Inc. The 4-foot Hydrax, which has an 8000-pound polished rod capacity, was designed to meet the increased demand for economical production of low volume stripper type wells of 50 barrels per day or less. Like all Axelson Hydrax pumping units, electrical motor or internal combustion engine may be used as a prime mover. Normal applications have shown requirements as little as ½ horsepower, making electric motor drive ideal in most cases.

One of the important features of the unit is simplicity of operation. A simple adjustment of the Axelson reverse valve located on the reservoir tank at ground level will provide a downstroke time ranging from two seconds. Upstroke time is determined by pump speed. Other features are wide range of application, simplicity of design, and ease of installation. Foundations or special footings are not required for normal operation. The unit is a pedestal type and mounted on the production tee.

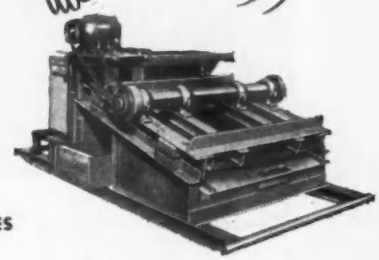
(This item supplements Axelson Manufacturing Co., Division of U. S. Industries, Inc., data on pages 333-376 of the Composite Catalog, 21st Edition.)

For more data, circle **No. E9** on Readers' Service Card, last page this issue.

Stainless Steel Regulator

Designed to withstand the corrosive effects of certain fumes, gases, acids and chemicals, a new stainless steel temperature regulator is now offered by Fulton

HUTCHISON MANUFACTURING CO.
6609 AVENUE U, HOUSTON 11, TEXAS



ALSO REMOVES SHALE

ALWAYS IN OPERATION WHEN PUMPS ARE RUNNING

Are you drilling a Wildcat Well?

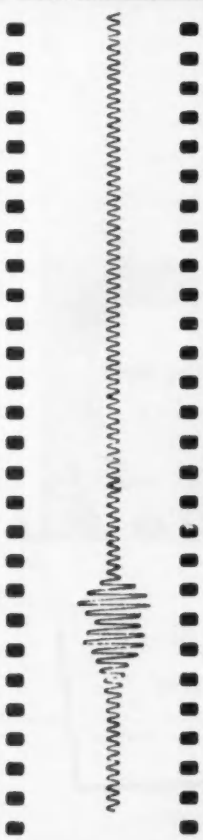
PROVEN GEOPHYSICS

The New and Improved Amazing Attractometer

The latest and most modern method of geophysical exploration that shortens the route to petroleum reserves by rigid instrumental recordings, indicating the existence or not of hydrocarbon accumulations, and approximate depth. Ten locations for a major oil company without error. Surveys conducted for cash fee and chance to earn small override, oil payment, leases or other interest, where saturation is indicated in commercial quantities. Information on request.

To establish conclusive proof of the accuracy of our geophysical work, we will, without cost to you, test and record a log of your well on tape, bearing your signature and ours, of your rank wildcat location, in advance of drilling, indicating the existence or not of petroleum in commercial quantities underlying the tested areas and approximately at what depth it may be found. The instruments are entirely self-operating during testing period.

GEOPHYSICAL SURVEY SYNDICATE
4133 Sunnyslope,
Sherman Oaks, Calif.
Phone STate 46903



Specimen of log tape indicating saturation with break in zone

GALLOWAY
PIPEGUARD
INTERNAL TUBING COATINGS

new positive protection against corrosion

Prevent costly corrosion like this.

Money saving protection for your oil or gas well tubing starts with *field proved pipeguard* coatings. Baked on for resistance to corrosion – air cured for paraffin prevention, these pipeguard coatings guarantee lasting economy.

- Protects against corrosion
- Prevents paraffin deposits
- Saves time by eliminating expensive workovers
- Insures *cleaner* transmission of any oil or gas product

HERE'S PROOF:

A major producer's* records proved Galloway Pipeguard (on 261 wells – 1,600,000 feet of pipe) was consistently successful in paraffin prevention and corrosion.

**Ask our representative*

FASTER SERVICE:

Galloway's new enlarged processing plant insures the most prompt service to the field and quality control throughout.

1601 CEDAR STREET • BEAUMONT, TEXAS
Write for a free brochure.

Please send me information about Galloway Pipeguard Internal Tubular Coatings including prices.

NAME _____

FIRM _____

ADDRESS _____

CITY _____ ZONE ___ STATE _____

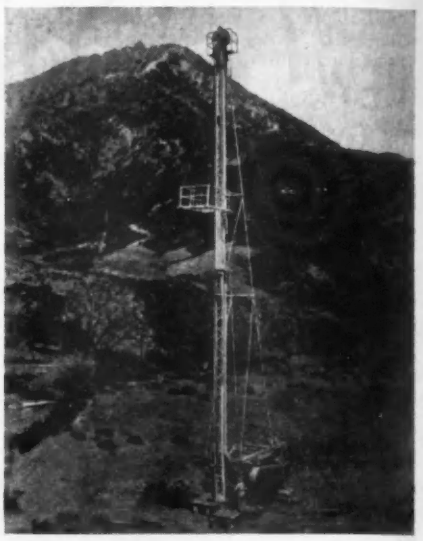
For more data on advertised products, use Readers' Service Cards, last page.

Sylphon Division of Robertshaw-Fulton Controls Company. According to Fulton Sylphon, the new regulator, called the No. 11061-R, was developed mainly for use in chemical plants. Other applications seen for the regulator are in plating rooms and in processes where ammonia vapors are present. It is also recommended for exposed locations.

In standard models of this control the entire upperworks are of stainless steel. The company said it will supply valves, as well as upperworks, in stainless steel, for use in extremely corrosive situations. The No. 11061-R is available in sizes from ¼ inch to 4 inches, and in temperature ranges between 20° F. and 455° F.

Similar in operation to other Fulton Sylphon regulators, the new No. 11061-R requires no external power source, such as compressed air, water or electricity to function efficiently. A large stainless steel bellows used in the thermal unit provides accurate and sensitive control over temperature.

For more data, circle **No. E10** on Readers' Service Card, last page this issue.



85-foot Servicing Derrick

A new 85-foot servicing derrick, designed especially to afford added height for rod and tube servicing without sacrificing portability, has been announced by Bucyrus-Erie Co., South Milwaukee, Wis. The two-section, power-lowered telescoping derrick lays down over the spudder for fast road travel and is available as special equipment for use with the firm's largest model oil well spudder—the 48-L.

Power-raised, the derrick has a built-in four-part tackle and over-size derrick hoist drum. In raising the derrick, 12 guy lines are set—four each from the lower section, the fingerboard, and the top of the derrick respectively.

A fingerboard is arranged to hold a total of 7920 feet of well tubing in 60-foot stands. The derrick can handle up to 60,000 pounds of tubing.

The new servicing derrick features a sturdy structural design similar to the standard 60-foot 48-L derrick. The lower section consists of 12-inch channels and the upper section is made of laced angles to form 11-inch channels. Reinforcing is added at the hinge pin, and a casing tackle strut is provided.

(This item supplements Bucyrus-Erie Co. data on pages 889-894 of the Composite Catalog, 21st Edition.)

For more data, circle **No. E11** on Readers' Service Card, last page this issue.

Pneumatic Industrial Valves

A new line of fast-acting, pneumatically operated industrial valves has been introduced by Minneapolis-Honeywell's Valve division.

The new line, known as Series 200, is available in two models, one a piston-operated throttling valve and the other a diaphragm-operated two-position valve. Both are especially designed to handle such gases as air, helium, nitrogen and argon, at pressures up to 10,000 pounds per square inch. The valves allow pressure drops as high as 6000 psi under flowing conditions. They work at temperatures from 40° below to 400° F. Even wider

Corrosion Rectifying Company Occupies New Office and Warehouse

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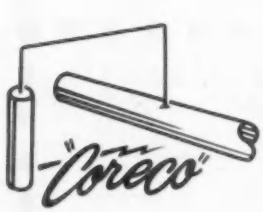
Wayne A. Johnson, President



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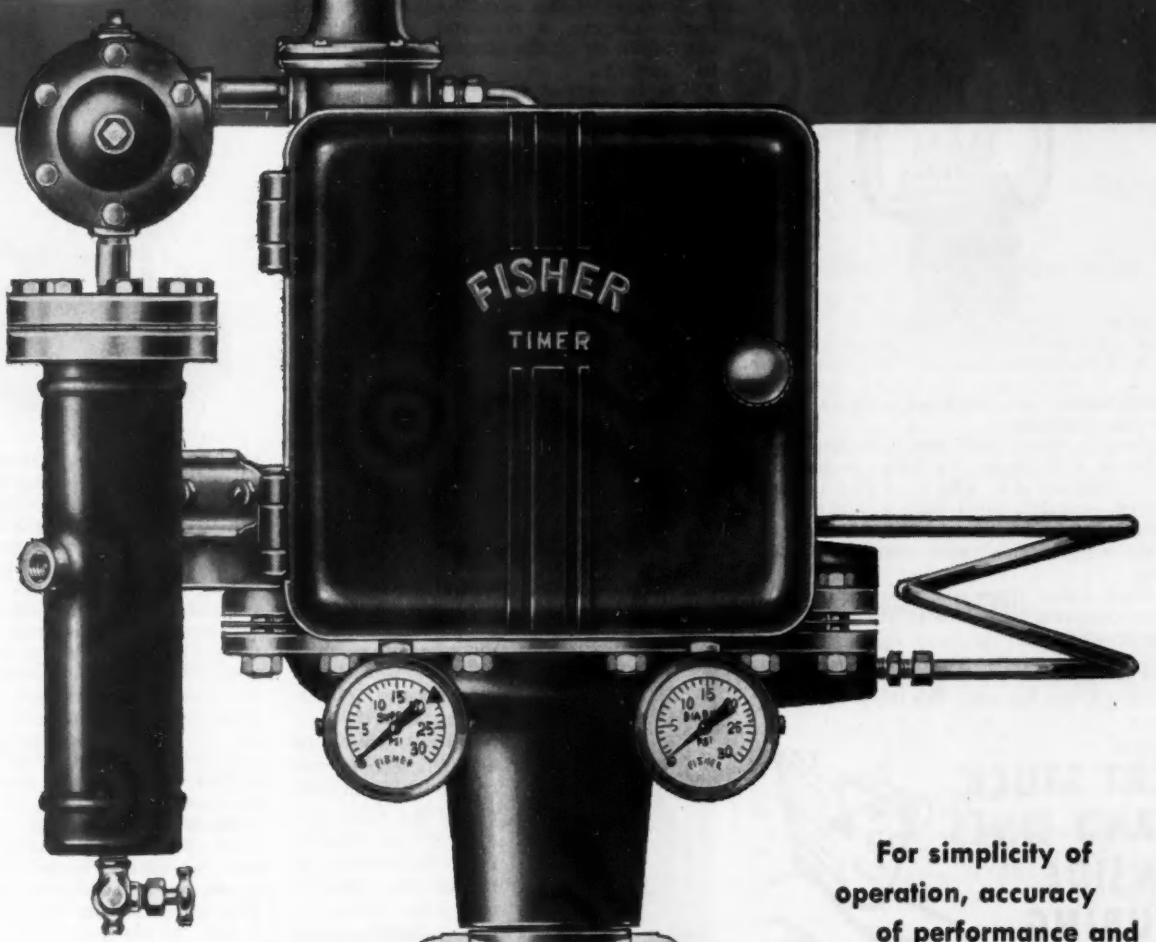

For simplicity of operation, accuracy of performance and all around dependability, the Fisher Series 4500 can't be beat!

Fisher Time Cycle Intermitters are used in every important oil field throughout the world.

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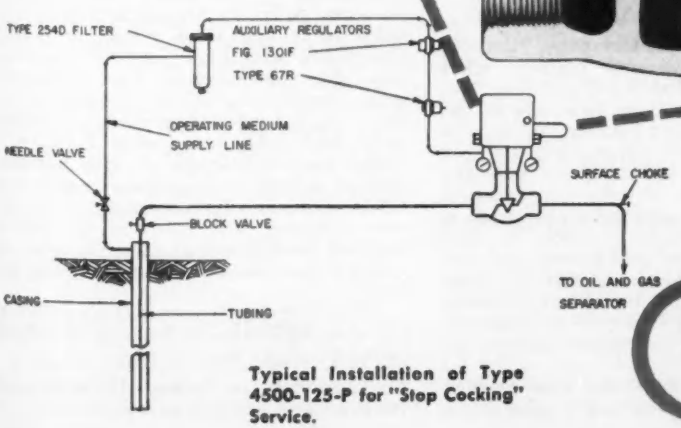

Typical Installation of Type 4500-125-P for "Stop Cocking" Service.

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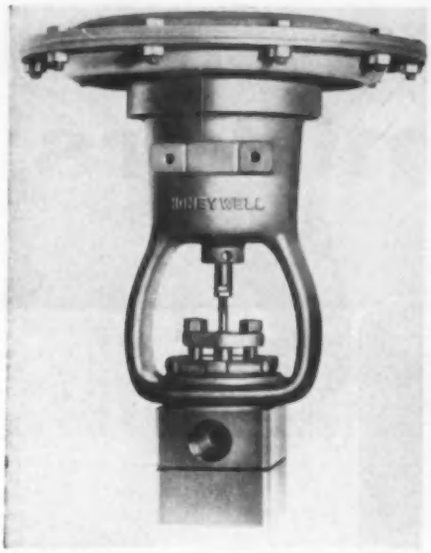

temperature variations are available in special versions.

Despite their small size (the throttling valve is 15⅜ inches by 13$^{5}/_{32}$ inches; the two-position valve, 10½ by 11⅝) the two valves' stainless steel bodies make them suited for heavy duty. They have split-body construction with clamped-in seat ring.

Both valve types are also available in hand-operated models with the same body construction.

For more data, circle **No. E12** on Readers' Service Card, last page this issue.

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KINLEY SAND LINE CUTTER

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Kline Wire Line Co.....OX 3-2731
WICHITA FALLS, TEXAS
Hudson-Eads, Inc. 2-3767, 2-8584, 3-4690

DRILLING

Fann Resistivity Meter

The new Model 88 Fann resistivity meter is unusually small and light—3 inches x 4 inches x 5 inches and 20 ounces. Carried like a camera, it measures resistivity of any liquid or plastic sample with accuracy to 2 percent.

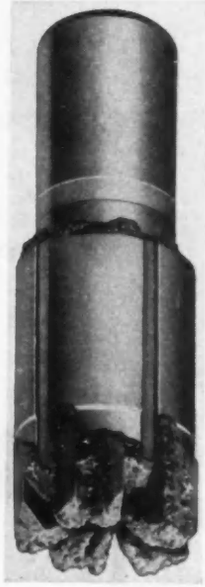
The instrument is direct-reading—there is no "booger" factor for either cake or filtrate. Made of the finest available components, all electronic parts are moisture and fungus proofed. The transparent sample holder functions with samples as small as .75 cc and is easy to clean. Battery-power is self-contained, with battery life from three to five years in normal usage.

Circuits are transitorized for compactness and long life. Leather carrying case is available.

For more data, circle **No. E13** on Readers' Service Card, last page this issue.

Servco Junk Mills

The Servco Co. junk mills were designed to mill junk inside the casing, drill complete bits which have been lost in the hole, and for clean-out work. They are similar to Servco CA whipstock mills, except that the blades of the junk mills are more heavily webbed with Servcoloy, a new process which suspends particles of tungsten carbide in a tough, elastic matrix so that hundreds of cutting edges are always in contact with the surface to be cut. As particles are worn away or torn from the matrix, new cutting edges are automatically exposed.



The new Servco junk mills are available in sizes from 3¾ inches to 11 inches O.D.

(This item supplements The Servco Co. data on Pages 4513-4524 of the Composite Catalog, 21st Edition.)

For more data, circle **No. E14** on Readers' Service Card, last page this issue.

Pressure Relief Valves

The Kinzbach Tool Company, Houston, has announced two new pressure relief valves known as Models 412 and 414. The difference between them lies only in the method of pilot valve loading and type of pilot valve. The new valves meet the need for a simple and accurate, yet safe and dependable means of relieving excessive pressures at strategic points in pressure systems. The hazards common to such complex systems are well known and protection of the equipment against overpressure, due to surges, line blocks, control failure, or human error, is essential for the safety of the operations and of the personnel involved.

The company states that line pressure is utilized for opening and closing these valves with opening pressure preset by application of dead weight or spring load. They are designed for instantaneous opening to full capacity and for automatic reseating with no chatter or wire-drawing at seat. These valves can be functionally tested at any pressure by hand lifting the pilot stem which operates them; opening pressure can be set accurately without flowing main valve. There are only two moving assemblies and all elements of the valve are easily accessible for maintenance and inspection. The stem, guide, seat and spring are all of stainless steel. These valves are suitable for operation at temperatures up to 300° F.; on special order 400° F. valves are available.

Model 412 denotes a ball seated pilot valve, usually dead weight loaded, but it may be spring loaded. The seating elements are a hardened stainless steel seat into which a hardened stainless steel ball is held by the pilot stem. When the force under the ball equals the force of the weights or the spring force, the pilot opens, causing the main valve to open. After the pressure in the protected system has bled down approximately 15 percent, the ball is forced down on the seat and the main valve then closes.

For more data, circle **No. E15** on Readers' Service Card, last page this issue.

Counterbalanced Pump

Something entirely new has been added to this 18-inch stroke pump with the furnishing of a counterbalanced eccentric. This reduces unbalanced forces normally transmitted to the pump foundation or platform. Also new are threaded fluid cylinder locks and rings which are interchangeable with those used on the valve pots. The redesigned Gardner-Denver surge chamber, which is available as an accessory, is furnished complete with boom and Gardner-Denver ½-ton hoist, with trolley and air hose, for the easy handling of fluid end parts. In addition to these new GXH features, the big mud pump has been designed with many of the famous Gardner-Denver construction features already proven on other pumps of the GX line.

(This item supplements Gardner-Denver Co. data on Pages 1869-1888 of the Composite Catalog, 21st Edition.)

For more data, circle **No. E16** on Readers' Service Card, last page this issue.

New Equipment Catalogs and Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Reader's Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card. Requests are transmitted to the manufacturer as soon as received by us for mailing of desired information directly to you.

Flow-Line Publication

The fortieth anniversary of the invention of the lubricated plug valve has been commemorated in a colorful, 20-page edition of The Flow Line, a Rockwell Manufacturing Company publication.

The magazine describes how Sven Nordstrom, a young Swedish engineer, invented the lubricated plug valve after his battle with a frozen plug cock ended with a bent wrench and the plug still immovably stuck. Also described are some of the experiences of the old-time Nordstrom valve salesmen as they attempted to introduce the new invention to the sometimes skeptical industrial engineers of the time.

The special issue contains a foreword by Willard F. Rockwell, chairman of the board of Rockwell Manufacturing Company, with which the Nordstrom interests became affiliated in 1933. A number of pictures of early Nordstrom installations, all still in service, are included.

To get a copy, circle **No. E17** on Readers' Service Card, last page this issue.

Wire Rope Cost Control

The Service-Score system for controlling wire rope costs is the subject of a new illustrated folder. Described is an easy method of fact-finding to increase wire rope operating efficiency and help to reduce supply and maintenance costs. Sample set of Service-Score stickers sent with the folder.

To get a copy, circle **No. E18** on Readers' Service Card, last page this issue.

Locking Tool Brochure

Otis Pressure Control has published a bulletin on its new Type W Otis removable locking mandrel assembly, a tool used to lock and pack off Otis removable subsurface flow controls. The literature describes the design and applications of the new tool, and also contains several illustrations of the assembly.

The Type W locking assembly is used to lock and pack off Otis removable bottom hole regulators, Otis removable tubing safety valves (storm chokes) and Otis removable bottom hole chokes. In addition, the Type W can be equipped with either a flow bean or plug bean and used as a bottom hole choke or as a tubing plug. The locking tool has a heavy-duty packing element and sets on slips. It can be landed at any interval in the tubing string, and does not require a landing nipple made up between joints.

To get a copy, circle **No. E19** on Readers' Service Card, last page this issue.

Detroit Diesel Bulletin

Detroit Diesel industrial power units and fan-to-flywheel engines for use in hundreds of standard and special applications are fully described and illustrated in a new brochure just released. Covered are horsepower ratings, dimensions and accessory information on single and multiple-engine models ranging from 56 to 761 rated brake horsepower.

To get a copy, circle **No. E20** on Readers' Service Card, last page this issue.

Rectilinear Recorder Book

Three illustrated bulletins on the first truly rectilinear writing galvanometric recorder, the recti/riter, and accessories are announced by Houston Technical Laboratories, Instrumentation subsidiary of Texas Instruments Incorporated. Bulletin R-501 is a six-page, two-color brochure thoroughly detailing the unique design, construction and operator convenience features of the recti/riter . . . ink-writing, strip chart recorder.

Its exclusive recti/rite system satisfies basic trigonometry in changing curvilinear motion to true rectilinear motion, thus inscribing a signal that may be measured directly with a ruler. Other outstanding features of the recti/riter are up-front accessibility to all controls and chart, highly dependable inking system, large, high-output torque magnet, and recording accuracy within 1 percent.

To get a copy, circle **No. E21** on Readers' Service Card, last page this issue.

BS&W Monitor Bulletin

Instruments, Inc., new bulletin describes the new BS&W Monitor, a device for measuring and controlling the b. s. and w. content of crude oil at automatic custody transfer installations. Developed and patented by Gulf Research and Development Co., the Monitor has undergone extensive field test prior to being licensed for manufacture to Instruments, Inc.

To get a copy, circle **No. E22** on Readers' Service Card, last page this issue.

Selector Valve Pamphlet

The National Supply Company has issued a pamphlet describing Win-Well Manufacturing Company's 7-way multiport rotary selector valve. The back cover has a complete flow chart on typical installations.

To get a copy, circle **No. E23** on Readers' Service Card, last page this issue.

Pumping Unit Folder

A special bulletin describing the newly-developed Hydrax, Jr., a small economical hydraulic pumping unit with a 4-foot stroke, is available from Axelson Manufacturing Company, Division of U. S. Industries, Inc. The Hydrax, Jr., is the smallest hydraulic surface pumping unit in use today and is recommended for stripper and low-production wells of 50 barrels per day or less.

To get a copy, circle **No. E24** on Readers' Service Card, last page this issue.

Long Stroke Pump Catalog

A new 12-page illustrated bulletin describing the Hydrax long stroke hydraulic pumping unit is available from Axelson Manufacturing Company, Division of U. S. Industries, Inc. These units have a 26½-foot stroke, a 32,000 peak rod load capacity and pump at a maximum rate of 7 strokes per minute. Specifications, construction, operation and application data are described in detail.

To get a copy, circle **No. E25** on Readers' Service Card, last page this issue.

Wire Rope Bulletin

In a current issue of Macwhyte Company's trade bulletin "Ropeology," the company announces that PREmium Whyte Strand is the name adopted for the company's "extra improved plow steel" wire rope. The bulletin announcement states, "PREmium Whyte Strand wire rope is 15 percent stronger than Monarch Whyte Strand improved plow steel wire rope. PREmium grade is best suited to extra heavy duty installations. Because of its 15 percent added strength, PREmium Whyte Strand provides a higher safety factor for such work.

To get a copy, circle **No. E26** on Readers' Service Card, last page this issue.

New Engine Literature

Four new engine case histories have been published by the Le Roi Division, Westinghouse Air Brake Co., Milwaukee, Wis. This brings to eight the total number of engine case histories published recently by the firm.

The two-page case histories use pictures and drawings to illustrate applications of Le Roi modern V-8 and V-12 engines of 540 to 4000 cubic inch displacement. Applications described in the case histories include: air conditioning, gas boosting, cotton ginning, irrigation, generator sets, oil well pumping and oil well drilling.

To get a copy, circle **No. E27** on Readers' Service Card, last page this issue.

Cathodic Protection

The pages of this brochure give you a quick look at the cathodic protection services and materials offered by Corrosion Services Incorporated. The sections included are casing protection, pipe line protection, magnesium anodes, selenium rectifiers, and a few pages about the company.

To get a copy, circle **No. E28** on Readers' Service Card, last page this issue.

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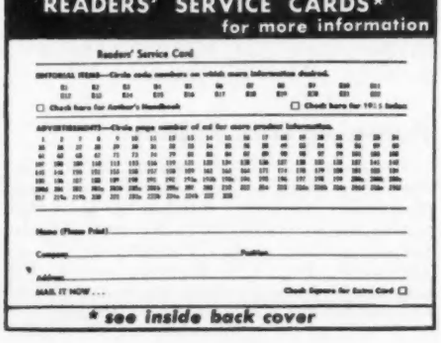
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